School Science and Mathematics

Vol. V. No. 9 Chicago, December, 1905 Whole No. 38

ON SCIENCE TEACHING. III.

By C. R. Mann.

Ryerson Physical Laboratory, University of Chicago.

When we take up the consideration of science teaching in its broadest aspect, and inquire how it should be related to other departments of thought, we find that the problem resolves itself into one of determining what is the common bond of unity between the sciences and the other subjects in the curriculum. This problem is seen to be closely allied to that of the acquirement of "culture" by students of science.

Before we can discover the means of adding "culture value" to science study it will be necessary to have some sort of an idea of what this thing called culture is. There seem to be many ideas abroad about it. It is often spoken of as a thing that can be put on as a garment, or acquired by "getting credit" in some school for numerous hours of work in numerous subjects—each taught by a specialist without reference to any of the others. It is a matter of general belief that the finished product of the engineering school usually lacks culture; and it has been seriously urged that this lack may be suppled by "requiring" the embryo engineer to spend a couple of years in culture work,—Latin, Modern Languages, Literature, History, etc. This means that we expect to broaden them by constructing in their mental barns several new stalls in which these newly acquired pets may be tethered. When the barn is filled with all kinds of stock,—so that it becomes a veritable Noah's Ark,—its owner is said to be cultured, becomes a "praeses juvenis," and receives his "diplomata, in hujus rei testimonium" duly signed and sealed. This suggestion implies that culture consists in a smattering familiarity with numerous branches of thought, without the student's ever having felt their inner connection or been brought to feel their real unity.

Matthew Arnold and others have given other definitions of culture; but perhaps the most comprehensive one is that developed by Hamilton Wright Mabie in his Essays on Nature and Culture. We there read:

"For culture, instead of being an artificial or superficial accomplishment, is the natural and inevitable process by which a man comes into possession of his own nature and into real and fruitful relations with the world about him." "The essence of culture is not possession of information as one possesses an estate, but absorption of knowlede into one's nature, so that it becomes bone of our bone, and flesh of our flesh. Its distinctive characteristic is not extent, but quality of knowledge; not range, but vitality of knowledge; not scope of activity, but depth of life. It is, in a word, the process by which a man takes the world into his nature, and is fed, sustained, and enlarged by natural, simple, deep relation and fellowship with the whole order of things of which he is a part." "Nothing brings into such clear relief the prevalent misconception of the meaning of culture as its identification with diligence of acquisition, or with studied pursuit of the graces and accomplishments of the intellectual life, instead of its identification with a process of growth patiently pursued for a life-time and as deeply rooted in the order of things as the growth of an oak." "To the man who puts himself in right relations with his fellows and the world, nothing is devoid of educational quality." "Among the most important of the ministers to culture—religion, art, literature, science, human relations, activity, and experience,—Nature holds a first place."

From these words, and from many others of like import in which the essays of Mr. Mabie abound, we may gather a conception of culture as a power of feeling relationships, as an attitude of mind toward all about us, and as an ability to become filled with a sense of the ultimate unity of Mankind, Nature, and Man. The teacher who wishes to become imbued with this spirit, and to learn what Nature (whose study science is) can do for us in the acquirement of culture, should carry a copy of these essays in his pocket, and read and reread them until he has become saturated with it.

But if culture is a power or process of this sort, how may subjects be presented in school so as to foster its development?

Breadth—so-called—obtained by multiplication of subjects studied, will not do it, unless those subjects are so interrelated that they are pervaded by a sense of unity; and this can only be done by paying heed to the source of their unity—the facts that each subject is a part of the grand total of human activity and that each man an epitome of mankind. Hence if we would present subjects in such a way that they are really correlated, we must learn how to do so from a careful study of their relations as manifested in the past history of the race. Thus for us scientists too the real solution of the problem before us appears to lie hidden in the history of our subject. In order to find it, we shall have to study that history in the most comprehensive way, and ponder well the relations that have existed between science on the one hand, and the humanities on the other at various times and in various places.

It is no small task that is thus set before us; for the true history of the development of human thought and feeling has not appeared. Histories there are in abundance of special topics or phases of that thought and feeling, such as histories of art, literature, poetry, music, mathematics, astronomy, dogma, rationalism, morals, politics, theology, philosophy, and many others; but which of these gives more than the faintest outline of the relations of the subject in hand to the others? Which of them attempts to detect the general evolutionary law of one subject and to see if it is similar in others? Yet a vast advance over the methods at present in vogue in science teaching could be made if each teacher would study such works as exist and try to trace for himself the relations between the various phases of activity treated by each—if he would try to present his subject more from the historical and concrete side, and less in the purely logical and abstract one—if they would try to connect the history of his special subject with the grander general history of thought, and to discover what similarities he can between the process of evolution in his science and that of other phases of human activity.

An example may help to make this clear. Physical optics did not advance at all as a science during the 18th century. By the student of nothing but physics, this fact is usually attributed to the overwhelming power of Newton's authority and the fact that he adopted a barren hypothesis to account for the phenomena of light. This explanation is probably true as far as it goes, but in

devising it the physicist did not look beyond his own immediate surroundings. He should apply his science to it and realize that it is at best only a wild approximation of small probability, because based on so few facts. Let him first ask what was being done in other lines at this period. This is the essential question.

First, we note that in the other branches of physics no great work was done during this period in any field save that of abstract dynamics, where we find Euler, Lagrange, D'Alembert, and their colleagues. Chemistry still dabbled with phlogiston till the later quarter of the century. Anatomy, Whewell tells us, though eagerly studied up to the end of the 17th century, was somewhat neglected during the first two-thirds of the 18th.

In the realm of literature Carlyle tells us that at this time "Whatever belonged to the finer nature of man had withered under the Harmattan breath of Doubt, and now, where the tree of life once bloomed and brought forth fruit of goodliest savour, there was only barrenness and desolation." And again, referring to the same period: "The two great features of the French intellect were formalism and scepticism. These became the leading intellectual features of all nations of that century. French literature got itself established in all countries; one of the shallowest that has ever existed. It never told man anything; there was never any message it had to deliver him. But on the other hand it was the most logically precise of all; it stood on established rules." He also called the 18th century: "spendthrift, fraudulent, bankrupt; gone at length, utterly insolvent."

The first encyclopedias were produced in this age.

On the side of religious and philosophical thought Leslie Stephan writes of that age: "The most conspicuous literary phenomenon in the latter half of the 18th century in England is the strange decline of speculative energy. Theology was paralysed. The Deists railed no longer; and the orthodox were lapped in drowsy indifference. In traversing this parched and barren district, we shall scarcely meet with one fresh spring of original thought; and our journey must be a weary one." And again: "A cold blast of scepticism seems to have chilled the very marrow of speculative activity. Men have lost their interest in the deepest problems, or write as though paralysed by a half-suppressed consciousness of the presence of a great doubter." (English Thought in the 18th Century, Vol. 1, p. 1 and p. 372).

Commenting on the progress in Education during this period Davidson writes: "In the first half of the 18th century no marked advance in education took place. It was a time of ominous calm, foreboding a storm." (History of Education. p. 211).

That this period, which culminated in both the American and the French Revolutions, was one of great turmoil in politics, is too well known to need comment. That it marks a crisis in the intellectual and spiritual growth of European Nations, is now a well recognized fact. Many other facts might be adduced to the point, but enough has perhaps been said to show that a broader solution of the problem concerning the optics is that the civilized nations of Europe were passing through such a mental and political crisis, that optics suffered along with the other branches of speculative thought.

These few hints may serve to give a faint inkling of the way in which the history of any one subject may be illuminated and made more vital by the comparative study of others. It may also serve to indicate roughly how physics or any other science may be made a real culture study. For if we believe with Pope that "The proper study of Mankind is man;" or if, as Mabie says: "It is profoundly true that the history of the race is the true educational material for the unfolding of the individual life;" we may see how any subject may be enriched with a vast amount of this truly educational material and thus become a powerful and priceless factor in any individual education.

From this point of view it is at once apparent why we science teachers flounder about and struggle so in vain to enrich and make vital the instruction we give. It is because we do not look beyond our own specialties. We are like a lot of potatoes sprouting in a dark cellar, and wondering why our sprouts do not flourish, but are white and anemic. All that we need is contact with the rest of the world. We need to get closer to Nature and to absorb the warmth of the greater human life about us. We do not need new and more ingenious apparatus in our laboratories; nor yet novel and elegant methods of demonstrating this or that principle; but greater outlook and wider sympathies,—in a word, less impedimenta, and more human life. For is it not still profoundly true that "one touch of Nature makes the whole world kin?"

Great as is the final task, we science teachers should not shrink

from undertaking it; for its accomplishment means nothing less than the complete vitalization of science as a means of education. Such work is the highest that can be done for elementary science, for it has been truly written: "The highest criterion of pure science is its educational value."

APPARATUS FOR INSTRUCTION IN METEOROLOGY

By Cleveland Abbe.

In the Monthly Weather Review for January, 1905, Professor Abbe makes the following suggestions on the equipment desirable in the school laboratory for the study of meteorology.

"In manual training schools, technical schools, colleges, and post graduate or university research schools, wherever the primary object is to teach and practise the greatest exactness of construction, observation, and investigation; there, of course, nothing but the best should be allowed. These schools are conducted by teachers who understand exactness; it is mostly the public grade schools or high schools that apply for advice as to apparatus for elementary educational purposes.

For high schools and lower grades, the object of whose instruction is to teach general principles and the elements of physics, expensive accurate measuring apparatus is not required. The scholar will learn general laws and principles better by making a rough instrument himself than by merely looking at a highly finished one.

When a teacher desires to maintain a daily weather record as a voluntary observer, he must be provided with the standard apparatus of the Weather Bureau. No cheaper makeshift will do. He need not buy a complete outfit, but what he has must be standard. But when such a record is kept only for local educational purposes as the beginning of a system of training for young pupils, expensive apparatus is objectionable, and the simplest (not always the cheapest) apparatus is most desirable, so that a youth may handle it and easily see how it works and what its source of error may be. For such cases the mercurial thermometer divided on its glass stem, the sling psychrometer, the wind-pressure anemometer, using a pendulous sphere or a square

plate, or a Lind anemometer, a home-made syphon mercurial barometer, a Campbell sunshine recorder with a burning glass as a substitute for the expensive sphere, these among others offer the desired simplicity, while sufficient to record the atmospheric phenomena abundantly for educational purposes.

It seems very inadvisable to introduce into elementary schools expensive instruments that are used for exact scientific work or exemplify the best methods of science, such as a Green-Fortin barometer, or the Robinson whirling anemometer, whose structures are complex and whose actions and corrections depend on a theory that can not be demonstrated by simple reasoning adapted to the elementary knowledge of the pupil. Let a youth learn about the more complex and precise physical apparatus after he passes on to college and higher technical schools. He will then come to understand the sources of error of the so-called "popular" instruments, and understand the lingo of the salesman of "school supplies" who recommends the wooden support of his barometer scale as making an absolutely constant and correct instrument, or his thermometer as equal to those of the Weather Bureau. The best part of education is to teach a man where to go for reliable information on matters that he has not himself thoroughly studied, and how to protect himself against imposition of all kinds."

THE TEACHING OF SCIENCE IN SCHOOLS.

By Henry A. Perkins.

Professor of Physics, Trinity College, Hartford, Conn.

The study of elementary science, or "nature study" as it is often called, is a branch of steadily-gaining popularity in the modern school. In many curricula it absorbs perhaps a third of the pupil's time, and probably much more than half his interest. Classes in elementary ologies of all kinds are supplanting the classics and more formal studies of the past. Whether this is an advantage or not is a question I shall not discuss; but no one will deny that it is of the utmost importance that these new studies, if they are to be of any real value, if they are to pro-

duce mental fiber of any strength, must be taught thoroughly and well. Grave doubts of such thoroughness inevitably assail many a college examiner after he has waded through the dreary morasses of mental confusion found in numerous entrance papers.

Last June the writer set an examination in physics based upon a well-known college text-book with questions of a fundamental character, and no more difficult than those asked of freshmen who have completed the first year's college course. The result was most discouraging. Many of the candidates did not attempt to answer but one or two of the ten questions required. Those who were more courageous floundered hopelessly through part of the examination, but showed a confusion of mind that spoke ill for the methods of teaching used in the schools they came from.

Before quoting from the papers of these candidates, it will be well to explain that physics is not one of the entrance requirements at Trinity, but like certain other subjects it may be offered to make up the requisite number of courses for admission. The candidate who passes it is then eligible to the second year's college course. In fact, he would not be allowed to take the first course, and count that toward his degree, on the assumption that he has already covered that ground once by his entrance examination. It is thus essential that the questions asked shall be similar to those put to students who have completed Physics I.

The first question was one on fundamental units, and here are some of the replies, taken not from the worst papers, but from an average selection:

"Angular velocity is the distance an object travels when it is thrown up in the air or on its downward course."

"Angular velocity is the distance a body covers in centimeters when moving in another direction to that which gravity would tend to make it go " (This was on the best paper handed in.)

"Acceleration is the speed with which an object travels."

"The unit of the C. G. S. system is the dyne, of linear velocity is the foot, of acceleration is the foot per second, of force is the foot-pound, work is the horse-power, of potential and kinetic energy is the foot per second."

"Energy is the power which *every* body has for doing work." (The universality of this dictum is delicious.)

"The momentum of a body is the rate of speed of that body per second over a certain space."

"The C. G. S. is the unit of force."

Two problems in mechanics were asked, one on a ball projected at an angle of 30 deg. to the horizontal, involving of course a very simple trigonometric solution. This naturally was beyond the ken of those who had not yet learned the meaning of sine and cosine. Another involved the calculation of the moment of inertia of two weights at the extremities of a revolving weightless bar. Neither problem was solved correctly by any one.

The theory of the simple pendulum was left untouched by most. Those who attempted it described how a pendulum swings, and said a little about kinetic and potential energy as exemplified by that useful illustration. Archimedes's principle was variously described. One attempt follows: "Archimedes's principle was based upon the fact that if a solid was placed in water, which exactly filled a receptacle, the water which overflowed would exactly equal the weight of the solid. This made it possible to weigh an elephant, for the water could be collected and weighed a little at a time."

Another is of the opinion that on account of the "impenetrability of matter, . . . when a substance is placed in water it must displace its own weight of water." This view of equal masses was quite popular; about half the papers made a similar assertion.

Such questions as the frequency of the note G# when C=256, or the proof of the electrostatic formula Potential $= \frac{Q}{K\,d}$ were quite beyond the scope of all but one or two, who made feeble attempts to answer them. But one would look for more information when such concrete subjects as the Wheatstone's bridge were called for, for there is at least some form of wire bridge in any school laboratory; so it was a genuine surprise to have a boy who came from an excellent preparatory school say: "Wheatstone's bridge consists of two bars (hor.) some inches from each other. Across them a string is strung, one end hanging over having a weight attached" (diagram here), etc. (Of course an attempt to describe some method for finding the modulus of elasticity of a wire.) Other attempts at the famous bridge gave incorrect diagrams, usually a faulty picture of the piece of ap-

paratus used in the school laboratory; and even the fundamental proportion was often incorrectly stated.

Questions on the electrical and magnetic units produced some amazing information.

"Susceptibility is the power of showing the slightest current."

"Magnetizing force is the power which does the magnetizing measured in volts and amperes."

"The manetizing force is the force required to magnetize a body."

"Magnetic induction is the magnetism excited inside a helix, although no electrical connection has been formed." One sees in this last reply what ideas were groping in the poor confused brain, but the wonder is how the clear-cut mental focus of a future bank president or manufacturer can evolve from such vagueness and inability of expression.

Apparently no one had ever heard of the diffraction grating, and the spectra of incandescent solids and gases are both hazily described as having "lines," by the few who ventured into the realm of optics at all.

These samples taken almost at random give an idea of the sort of paper that was handed in. Of course, some questions were answered correctly, but the impression left in the examiner's mind was one of having come in contact with an intellectual fog, and his belief in school science has been (perhaps unfairly) correspondingly shaken.

As physics is the author's department, this discussion must necessarily take its departure from that subject, and I am convinced that work in what might be called the more descriptive sciences, such as botany or geology, or even chemistry, is of a more satisfactory nature. Physics, next to mathematics, is the most exact science in the sense that there are known to physics more fundamental laws capable of exact mathematical expression than to any other science. Even astronomy does not precede it, for the exact position of astronomy is a branch of mechanics, and the science of astronomy is still in its infancy. In teaching such a subject, then, one cannot lay too much stress on the underlying principle, the law behind the experiment, that the experiment is only intended to illustrate. When a certain phenomenon follows by an unassailable chain of deductions from a certain great principle, the experimental demonstration of this

phenomenon fails entirely in its purpose if the connecting logical links are not understood. And it is this lack of the logical or mathematical background to the experimental course that seems to me most apparent in the papers just discussed. The boy has carefully plotted the field about a magnet with the aid of a compass, but to him it is only the particular case of a compass and a magnet, and underlying notions of magnetic induction, tubes of force, law of inverse squares, etc., have nothing to do with the diverting little task in hand. The teacher perhaps has a class of thirty or more working together in the laboratory, and he is able to do little more than see to it that the experiment is done correctly, a neat report handed in, and certain explanatory references given to the pupil, who goes out with a recollection of only a certain particular example of a great law. If that law is presented to him in a slightly different form, he is utterly at sea, and flounders about for some support from among the concrete experiments that lie scattered about in his mind, unconnected and far apart.

This clinging to the concrete belongs to extreme youth, so the sciences that deal largely with the classification of concrete cases are better taught in our schools, and are usually more palatable to the pupils. By the time a boy is seventeen or eighteen years old, it is a mistake to let him cling too closely to the concrete. When he thinks of numerical relations, he no longer has to cut imaginary apples into fractions, or distribute oranges in certain ratios among little boys. Why, then, is he not able to grapple with the abstract generalizations of science? I do not mean that he should abandon the laboratory exemplification of the laws he is learning, but the principle should be made the central idea which experiment is only to prove and illustrate. Of course, historically speaking, experiment preceded principle, at least in most cases, but the inductive method in teaching is far too apt to confuse the pupil, who seldom has the maturity of mind necessary for unaided generalization. Moreover, it is the glory of modern science that new phenomena can be predicted from known laws, and the deductive side is to-day as essential to progress as the inductive.

The cause of this unsatisfactory condition, at least in the teaching of physics, lies largely in the text-books used in schools. Why must the boy taking physics in his last year at school study

from the childish book often used, when if he begins the science a year later in college he studies from such authors as Watson, or Hastings and Beach, or Carhart (to mention only a few admirable college textbooks)? Surely, a year cannot make so much difference in his mental equipment! It will be urged that the books named above involve an understanding of trigonometry. True, but the amount of trigonometry needed by the student of Watson, for instance, could be readily mastered in three or four lessons, so this is no serious barrier to the teacher who really wishes to use a "college textbook." In many elementary courses no textbook is used, and the lecture system is followed. This may give satisfactory results in some subjects, but in physics it cannot be too severely condemned. In order to train the student to think, he must be compelled to work for himself; and though the lecturer may give references and advise study, those who have tried it know how hard it is to exact the outside work so necessary in a mathematical science like physics; and the ability to wrestle with a difficult problem or concept is not fostered by what may be termed the "kindergarten method" in science.

Too little time in the classroom, or, what amounts to the same thing, a disproportionate stress on the laboratory end, is also in part the cause of the evils we are discussing. This would not be so if classes were small, and the instructor could devote himself individually to his pupils, thus making the laboratory a more efficient lecture-room; but generally the classes are too large, and the pupil depends upon printed directions, and an inexperienced assistant instructor, so the two or three hours spent in the laboratory are not the equivalent of a well-conducted recitation involving a preparation of an hour or more of hard study.

Among the causes of inefficiency in teaching school science, that which one would least anticipate is the extraordinary opinion which seems to prevail among school boards and principals that any youth who has had a year or two in a science at college is capable of teaching the subject. This careless attitude toward a field rapidly overtopping many more time-honored subjects of school instruction, is almost inexplicable. Why should a teacher of Latin be chosen with so much more care than the teacher of physics and chemistry? With the increasing reaction in favor of science, this is the more surprising. If science is to supplant the classics in popular esteem as a fitting for an active useful

life and the development of a well-trained mind, then let the teacher be one of sound knowledge as well as high intellectual ideals, and not merely a genial spirit who can play football with the boys in recess and bluff successfully when cornered by an inquisitive pupil in the classroom. I have seen appointments made by excellent schools that for unfitness on the part of the appointee rival the political appointments of a Tammany administration unchecked by even a pretense of civil service restraint.

If science cannot be taught well, it is far better to let it alone in preparatory courses. The final result will be more satisfactory, even to a boy who means to study engineering in college. The truth of this assertion was well illustrated in the writer's experience by the case of a pupil who, though far from dull or lazy, was almost the poorest in his class. On being questioned, he replied that he had had physics in school, and when he came to study his lesson it seemed familiar, and he was tempted to trust to his recollection of what he had learned in school, although his recitations always showed that knowledge to be valueless. If he had never had the subject before, he would have been forced to work and might have learned something. The school that has a long list of science courses on its catalogue's pages is falling in with a popular fad. I do not say the fad is wrong, but like all fads it is capable of abuse, and unless each of the courses is conducted at least as well as the course in Xenophon or geometry, requiring as much real work by the pupil and with the same definite results, the course is worse than a sham. Let the school authorities face the fact that in science, as in all other activities, good results can only be produced by skilled workers, and the skilled workman is more expensive than the untrained novice. Either the best or not at all should be the policy of every school that contemplates adding a course in science to its list of studies, if that course is to be anything but a bait for the children of unsophisticated parents, and a diversion more or less demoralizing to the pupil.—*Scientific American.*

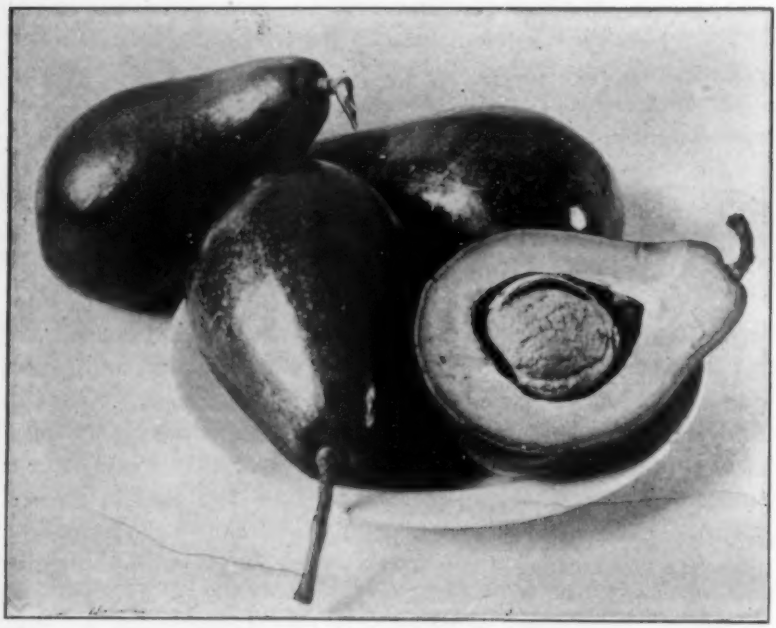
TROPICAL FRUITS.

By Mel T. Cook.

Chief of the Division of Vegetable Pathology of the Cuban Agricultural Experimental Station.

IV. AGUACATA.

Let us now consider some of the fruits less common to our northern markets. We have all heard of the Aguacata or Alligator Pear. The original Spanish name for this fruit was Aguacata, but the English speaking people have corrupted it into Avocata and Avocado.



It belongs to the Family *Lauraceae* and to the Genus *Persea* which is quite large and well distributed in both old and new worlds. The common avocata is *Persea gratissima* Gaertu., and is a native of the American tropics, but has been introduced into many other tropical countries. The trees are 25 to 40 feet in height and 12 to 18 inches in diameter. The wood is light or reddish brown and very brittle. The leaves are thick, alternate and bright green. The flowers are white or greenish and in panicled

fasicles, usually perfect; six-parted calyx, no corolla, twelve stamens and one pistil. The fruit is pear shaped, occasionally spherical, green or purplish, and with a single very large seed which separates readily from the firm, buttery pulp. This fruit is considered one of the greatest delicacies of the tropics and is

eaten by all the natives. People from northern climates at first express a very great dislike for this fruit, but soon become very fond of it. The fruit is cut open, the seed removed and the pulp flavored with salt, pepper, vinegar, etc., to suit the taste and then eaten with a spoon very much as we eat musk-mellons and cantaloupes. It is also used in salads. There is an increasing demand

for it in northern cities where it brings a good price, but it has the very great disadvantage of being a poor shipper. There are a great many varieties throughout tropical America, but thus far very little attention has been given to their cultivation and improvement. It is also grown to some extent in Florida and California.

Persea carolinensis Nees., is found as far north as North Carolina, and furnishes a good wood for cabinet work. *Persea catestyana* is a small shrubby Florida species of no especial value.

V. MANGO.

We have all heard of the Mango, but the fact that the common name is also used for other plants has led to many vague ideas concerning it. Most of us are surprised to learn that it belongs to the family *Anacardiaceae,* which is the family of the poison ivy of the north and many other poisonous plants. However, all the members of this family are not poisonous, and this is one of the species which is most important as a tropical food. It belongs to the genus *Mangifera,* which contains about 27 species. The common mango is *M. India* Linn, and is of South Asiatic origin. It was first introduced into Brazil and thence into the Barbadoes, and has gradually spread throughout tropical America. It is also grown to some extent in Florida and Southern California.

The tree is 30 to 40 feet in height, leaves thickish, long and narrow, flowers small and in terminal, pyramidal panicles. The fruit is kidney shaped, but much larger at one end than at the other and three to five inches in length. It is fibrous and juicy, and has the odor and flavor of turpentine and like most other tropical fruits the northerner must acquire a taste for it, but as a rule this does not require much time and most people become very fond of it. It is a subject for much improvement by cultivation and selection, and there are already many very delicious varieties. It is one of the best of tropical fruits and is destined to find an important place on our northern markets.

VI. MARANON OR CASHEW.

This belongs to the same family as the mango, but the fruit is quite different. It is the *Anacardium occidentale* Linn., which is so well known to science. The trees are usually not more

than 20 feet in height, but may reach 30 or even 40 feet. The leaves are large and oval, and have quite a different appearance in comparison with the mango. The flowers are similar to the mango, but somewhat larger and more showy. The fruit instead of being the enlarged ovary as in the case of the mango is the enlarged and fleshy receptacle which forms a large, pear shaped, fleshy, red or yellowish structure two to four inches in length. On the end of this fruit is borne the nut which is developed from the ovary and corresponds to the fruit of the mango.

This plant contains considerable poison which acts similar to poison ivy, but is largely concentrated in the nut. The fruit has an acrid, peppery taste and is not poisonous. It is used extensively for food. The nuts are roasted, which drives off the poisonous properties and are then used for food also. However, the roasting is rather a delicate process and should be done only by experienced persons. This plant has many local uses and it is very probable that its further study will result in its becoming of much greater value especially as a medicinal plant.

IDEALS IN THE TEACHING OF MATHEMATICS.

By H. E. Slaught.

The University of Chicago.

A suspicion that there may be wide room for improvement in respect to the teaching of Mathematics is aroused by any serious attempt to explain the dislike for this study shown equally by high school pupils, college students, and people in business and professional life. That such dislike exists among a considerable percentage of school and college trained men and women cannot be denied, nor can it be satisfactorily explained solely on the basis of predilection and home environment. Certainly these play an important part in determining the likes and dislikes of students, but who can doubt that the influence of a strong and inspiring teacher is more potent in this respect than any other factor?

There is this distinguishing characteristic of the subject matter of mathematics—it means very little or else exceedingly much to the average student; there is no middle ground; his work is either that of the parrot or else that of the logical thinker. In memorizing a poem for the English class, or a chapter for the recitation in History he may gain some real benefit even without much comprehension of the laws of poetry or of the logic of events, but merely to memorize a demonstration in Geometry is worse than useless; the language is jargon and the successive steps are meaningless without a clear comprehension of the logic involved.

This well defined difference between mathematics and other branches of the curriculum would seem to explain further why so large a number of students speak with warmth, or at least with toleration, of their work in most other subjects, while they delight in inveighing against mathematics. Believing as we do that the study of mathematics under thoroughly and highly qualified teachers, and with wise selection and clear presentation of subject-matter, should lead not only to fair logical understanding but to a reasonable degree of appreciation and interest on the part of practically all students in high school and freshman courses; and yet admitting, as we must, that this status is far from realization, no apology is needed for suggesting some of the ideals which, it seems, should be kept in view with respect to the teaching of mathematics.

In teaching more than in any other profession, save the ministry, are high standards of life and conduct demanded. The teacher more than anyone, save the parent, and frequently even more than the parent, exerts a determining influence upon the young people under his care—a deteriorating influence if his moral standards are low, an elevating and refining influence, if they are high. Likewise the intellectual standards of a teacher are reflected in the pupils, both directly and indirectly. A teacher who is continually striving to grow in mental breadth and power and especially to gain greater mastery in his particular field of work, not only becomes a better teacher thereby, but also widens and deepens his influence among his pupils. In fact if we may rescue a good word from the technical vocabulary of philosophy, the teacher should be an *idealist;* not, indeed, a believer in the unreality of matter and things, not a visionary with head in the clouds, proposing and attempting impossible and impracticable schemes; but one whose ideals are high and at the same time clearly defined and capable of approximate realization, and whose standards of life, both moral and intellectual, are pure, inspiring, and uplifting.

The teacher should also be an *optimist,* not in the sense of ignoring the bad nor of condoning the mediocre, but in the sense of believing the best, looking for the best, and finding the best in his students. Many a man owes his career in life to some teacher who believed in him while a student. Sarcastic criticism, cynical taunts, and pessimistic predictions may serve to goad a certain few to harder work for the time being; but in general, latent intellectual powers do not develop in such an atmosphere. On the other hand timidity and self-distrust and even indifference and carelessness are banished in the presence of a teacher whose words and manner indicate confidence in honest effort and the expectation that everyone will do his best.

Again the teacher must be an *enthusiast*; not one who poses in sensational attitudes, or who astonishes with freakish statements, or who gushes with lightsome sentiment; but one who, believing in his work and filled with his subject, is capable of warming up with genuine enthusiasm in the presence of his pupils. It takes fire to kindle fire and enthusiasm is contagious. Pupils catch it from teachers and spread it among their mates. They are also quite as easily affected by the soporific influence of the lifeless

monotony and humdrum routine which pervades the class whose teacher has no enthusiasm in the work. Enthusiastic interest in ones work lies near the foundation of successful attainment and the teacher who is wanting in this characteristic falls far short of the power a teacher should wield.

Finally the teacher must be a *specialist*. It is no longer so common a practice for schools to "breed in" their immediate graduates as teachers. The grammar schools now demand special preparation for all phases of their work. The high schools demand college graduates. The colleges demand men of University training. A teacher of algebra or geometry whose mathematical experience does not extend far beyond these subjects has too limited a range of knowledge and too narrow a view of related truth to be entrusted with the guidance of students in these subjects. The successful teacher will not only possess thorough knowledge of the subjects relating to his work, but will himself be an independent thinker, at least, to the extent of formulating afresh in terms of his own perception the truths already known, and thus he will be constantly incited to search for truths which, new to him, may lie close at hand, and the discovery of which constitutes the strongest mental stimulus for the teacher.

Let us then consider a teacher of mathematics whose mental and moral standards are high, whose personality elicits from the students their best endeavor, whose enthusiasm dispels the monotony of the daily routine and whose special preparation implies a certain and wide command of the work in hand: What may we assume should be accomplished by a teacher who approximates these ideals?

It will be admitted that the successful teacher must have good order in the class room, must hold the attention of the pupils to the matter in hand, must induce them to learn the lessons assigned and must secure all these results not in a perfunctory manner nor by virtue of the commanding authority vested in him, but by reaching in some way the inner impulses and controlling motives of the student. Without this deeper influence the teacher is only a lesson-hearer, a task-master. Even good order, attention, and tasks performed, are not necessarily indications that the highest end is being attained in the teaching of mathematics; for, if the true spirit is lacking, even these may be only forms of compulsion

which lead to dislike or even disgust on the part of the student. They do, however, follow as natural and certain results when once the student is aroused to a genuine and enthusiastic interest in his work. Without this inner desire to investigate a subject, and without the personal interest in following its development, which genuine teaching inspires, the student's work is lifeless and fruitless.

The most important duty, the highest privilege and the crowning success of a teacher is to inspire the students with a desire to learn, to awaken and sustain in them a genuine interest in what they are learning, and thus to stimulate them to put forth their highest endeavor because of this desire and interest.

What resources may the teacher of mathematics draw upon in accomplishing this great end? What are some of the elements which contribute to the development of such interest on the part of the student?

1. Interest in a subject is aroused by discovering its relation to previously known subjects and to possible later investigation. A student finds no pleasure in working blindly; like a sailor he is always interested in taking his "bearings." Mathematics is a great field of interrelated truth and it cannot be assumed by the teacher that the average student, if put to work *anywhere* in this field will find his own bearings before he becomes discouraged and lost. To pore over rules and exercises and formulate laws, without any idea of what it is all about; or even to draw graphs and compute tables and perform concrete experiments with levers and weights and balances, without some conception of the relation of these things to the end in view, is too great a strain on the faith of the average pupil; and without faith in the outcome there is loss of interest in the process and finally failure or disgust with the whole matter. But a preliminary study which gives the student his bearings and leads him to appreciate the relation of the work in hand to his previous mathematical study puts the student at ease with the teacher in a field already familiar and at the same time affords a new and broader view of known subjects while leading up to the new. Such a scheme is effective with every new topic undertaken, not only at the beginning, but whenever the maze of details threatens to confuse the outcome and the student is in danger of losing his bearings and becoming discouraged.

2 A second essential in arousing interest is that the student shall become convinced of the utility of the work. Let him begin to experience the pleasure of solving some practical problems by means of the cold, dry formulae and at once his interest is stimulated. Digging bait is monotonous and uninteresting work except for the pleasurable anticipation of catching fish. So deducing rules and memorizing formulae have little power of attraction to the average student until it is seen that these are components of a powerful machine for removing obtsacles in the path of scientific discovery—and, for solving the problems which arise in connection with the practical affairs of life. The teacher should constantly aim to show the useful side of mathematical study. This is comparatively easy in arithmetic, geometry and trigonometry, and yet how often even these subjects are taught in the most formal and perfunctory manner, with no sign of life in the subject and none in the pupil. With algebra, and especially college algebra, it is more difficult to hold to the concrete and practical applications, but with analytics and calculus, the field widens out and no good excuse can be given for mere formula work in these subjects. Perhaps the most important service which can be rendered by the teachers of mathematics of the present generation is to rescue the mathematical curriculum from the stigma of "impracticability" which has long rested upon it.

3. A third element which may be made to appeal strongly to the interest of the student is the beauty of many mathematical forms and processes. Symmetry in geometrical figures and in algebraic expressions, remarkable properties and relations, as in Trigonometry, analytic geometry and calculus, may be made to play an important part incidentally in sustaining interest. Formulae may be stored away in the dark like dried fruit or they may be made to satisfy a certain aesthetic taste by properly exhibiting their "display" qualities, as the merchant adorns his store window with cans of fruit so treated as to preserve the symmetrical forms, attractive colors, and beautiful curves. A recognition of the attractive features of mathematics may have little weight in this practical age as over against the utilitarian aspect, but the skillful teacher will discover many suggestions of beauty in mathematical forms and processes with which to freshen and stimulate the interest of students who might otherwise rebel

against the hard work or grow weary of the monotony involved in the cold logical processes.

4. A fourth element, perhaps the most effective, in arousing and maintaining the interest of the student is clearness of presentation and explanation on the part of the teacher. This involves not only a clear understanding by the teacher of the subject in all its bearings, but also an appreciation by him of the difficulties experienced by the average or slow student. This means not lecturing but eliciting, drawing out, awakening. It means studying the case of each student and adapting the treatment to his need. It requires patience, sympathy and devotion to the work. Contributory to clearness are (1) a careful introduction leading up to each new topic before assignment; (2) exact and clear statements of principles involved; (3) translation of every formula into words; (4) many sided discussion of every topic by teacher and student, for example, several statements of the same problem from different points of view and discussion of the relative merits of these statements; and (5) frequent tabulation of results and summing up of principles.

It seems comparatively easy to tell how to arouse interest and to make a subject clear to a class of students, to tell how to be a successful and inspiring teacher, and yet how difficult it is to accomplish! Those who can do it most satisfactorily may be least able to tell how, and those who can tell how most smoothly may be least able to do it. It is sometimes said that a teacher is born not made. At any rate to be an inspiring teacher is surely an ideal worthy of the highest aspiration and whatever may be our gifts by birth we may certainly gain much in this direction by observation, comparison and study. To this end the great activity during the past few years in the organization of associations of teachers of mathematics is full of promise for the future. These associations indicate the awakening of an interest among the teachers which is certain to produce results.

The lines of renewed activity which now seem to be receiving the most attention are (1) graphic representation in connection with all analytic work; (2) correlation of related subjects such as physics and mathematics, and the closer union of the different branches of mathematics as algebra, geometry and trigonometry; (3) the application of laboratory methods to mathema-

tics which means, in brief, more actual work by the student in class and less talking by the teacher.

These constitute the triune watchword of the present mathematical renaissance,—*graphics, correlation, laboratory.* These words do not indicate new methods but they indicate renewed activity along lines which are sure to create fresh interest in mathematical study and to transform cold, dry, theoretical processes into living and concrete contact with the practical world.

With respect to graphic methods we are coming to understand that pictures which are so effective in fixing ideas in childhood are just as useful for this purpose as we grow older. Indeed the graph may not only serve to illustrate the idea already conceived but may also be used to lead up to the discovery of ideas. The graph has not only become indispensable for tabulating and showing to the eye at a glance long series of results or changes such as commercial statistics, weather indications, etc.; but it has come to be recognized as an instrument of investigation for determining results in architecture, mechanics, engineering, etc. The chief caution necessary is that the graph is not an end in itself but a means, and should be used, therefore, not to supplant analysis but to supplement it. They must go hand in hand. The student who can devine a result by a graph but does not know the analytic basis is as far from a real mastery of the subject as the one who can reach the conclusion by a rule or formula but cannot interpret it by a picture. Both are essential to a complete comprehension. The analysis and formal solution have been emphasized too much and the graphic interpretation too little. The present tendency is likely to throw the balance the other way while what is needed is an equilibrium between the two.

With respect to correlation of subjects we are coming to realize more fully the close inter-relation between pure and applied mathematics and between the various branches of pure mathematics; and that the real interest of a student is bound to center not in the abstract principles of the subject but rather in the concrete things which can be done by the use of those principles; and hence that theory and application should go together; and further that the various subjects, such as algebra, geometry and trigonometry are only different tools for working toward the same end and should be studied as well as applied in correlation with each other.

LOGARITHMS IN THE FIRST YEAR OF THE SECONDARY SCHOOL. (I).

By G. W. Myers.

The University of Chicago.

FOREWORD TO THE TEACHER.

It is an educational axiom that the program of studies of both the elementary and secondary school are to be drawn up with chief regard to what constitutes the best education for the pupils of the ages falling within the period of the respective schools. In other words, the hypothesis of curriculum makers for the elementary school is that pupils are to get only an elementary education; and of those for the secondary school, that pupils are not to have a collegiate education. Contrary to common opinion, both academic and lay, the interests of the comparatively few fortunate pupils who can go on with their school work is not jeopardized by this procedure. Life is a continuous growth and the best provision for present interests is necessarily the best provision for future interests. For obvious reasons, the later years of both elementary and secondary schools should give large recognition to subjects and topics of a *vocational* character.

The majority of our people will find their lot in life cast with some phase of the commercial or industrial life of the nation. This will be increasingly true as the years go by. No hysterical regard for so-called higher academic ideals should blind us to the manifest duty of aiding young persons to sieze the problems of commercial and industrial society in a masterful way. The much-vaunted danger of too greatly saturating our educational system with the spirit of modern commercialism and industrialism should not frighten school men from their manifest duty of aiding to make an efficient citizenship. It is important educationally as well as practically that the pupil be helped to a knowledge of the ways and means of bringing his academic possessions to bear on the problems of real life. The work of society and of the school are not mutually antagonistic forces, competing for supremacy. On the contrary they are allies co-operating to attain the common end of enlightened efficiency of citizens. If then, out of school influences are coming more and more to be felt in the school, the tendency should be embraced and encouraged, not dreaded and resisted by the school men.

The early years of both elementary and secondary schools are perforce given largely to acquiring the technique of studies and to text-books, always more or less out of date and out of touch with the current interests of the people. This technique becomes valuable only by bringing it to bear in both the high and elementary school upon its uses in such practical matters as are commonly accepted as being worthy the best efforts of the best men.

This is, perhaps, true to a greater degree in arithmetic and in high school mathematics than is the case with other subjects or with even the more advanced mathematical subjects. It is indeed commonly admitted that many topics should be introduced into arithmetic because of the practical insight into business that they are capable of furnishing.

There is, perhaps, no arithmetical topic falling within the ready comprehension of grade pupils which has a higher practical value than logarithms. The whole business of computation outside of the schools—beyond the mere keeping of accounts—is now-a-days reduced largely to mechanical or to logarithmic methods. Beyond the mere additions, subtractions, multiplications, and divisions of simple arithmetic, practically all numerical problems are solved by the aid of logarithms. Most persons, who attain to positions of any particular significance, are compelled to acquire for themselves, after they leave school, such a knowledge of logarithms as is necessary for their work. Some practical men are not slow to call our elementary and secondary schools to account for spending so much time on topics of no great cultural value and of no practical value, to the neglect of such important topics as logarithms. They argue rightly that pupils of the eighth grade could and should be put into at least a measure of knowledge of the uses of logarithms, for the sake of making rational and intelligent much of what must otherwise remain meaningless, and be done by rule-of-thumb methods. The treatment of logarithms, to be given in subsequent pages, is advocated for eighth grades that are taught by persons who are themselves familiar with logarithms and their use. It is here offered for first year high school teachers, who are seeking to put more meaning and worth into the first year of mathematics by the extended use of computational problems. It is a first rudimentary treatment of the subject, sufficiently complete to make

common logarithms a rational tool for use by classes in computational work throughout the high school course in mathematics, and requiring only such preliminary matters as a pupil of arithmetic has had when he has learned *square root.* One good argument for this sort of study of logarithms in the eighth grade is that it puts a motive into the learning of the extraction of square root, a process which usually seems pretty useless to eighth grade pupils. A strong argument for not delaying the study of logarithms beyond the first year of the high school is that the introduction of laboratory methods and of more real problems into high school mathematics, both of which are generally recognized as desirable, means more computation by the pupil, the tedium of which is greatly relieved by logarithmic methods, while the mastery of the methods has a high practical and educational value for him.

Some sort of treatment of logarithms is, however, quite generally attempted even now in the first year of the high school. Most practical teachers admit the customary treatment of the texts too difficult. The college man would solve the difficulty by "postponing the subject until it can be treated rationally and thoroughly." High school teachers know this is bad procedure with pre-collegiate pupils. Some high school men would be satisfied with "merely teaching pupils *how to use* logarithms." This is irrational, unnecessary and consequently also bad. The method to be explained later obviates the difficulties of these suggested plans and, in addition, has the historical argument in its favor.

The writer is as ready as anyone to refuse admission to the elementary and secondary curricula of any subject of such nature as to make necessary a mechanical treatment of it. Even so practical a topic as logarithms should not be taken up the first high school year if it is not capable of rational treatment without too great difficulty. Believing that the use of logarithms is easily capable of rational treatment with pupils of even the seventh or eighth school years by a capable teacher, the writer purposes to put into form for teaching the more important aspects of common logarithms and their use for the seventh, or eighth, or ninth grade, dependent upon the quality of the teacher. The second paper will develop the subject and give a three-place table for use with classes and the third will deal with the uses of logarithms.

THE HISTORICAL ARGUMENT FOR TEACHING ARITHMETIC, GEOMETRY AND ALGEBRA TOGETHER IN THE FIRST YEAR OF THE HIGH SCHOOL.

By Willard S. Bass.

Francis W. Parker School, Chicago.

The history of mathematics sheds much light upon the way in which mathematical truth enters the human mind and the teacher who is seeking the best methods to present mathematical truths to his pupils, will find in many cases that the best procedure, is to present the matter in the same manner as it first appeared to its discoverer.

When, however, the teacher tries to obtain from the history of mathematics the best order for the presentation of topics, a difficult question at once appears. To what extent is the historical development of subjects the best one for the pupil to follow? It is manifestly unwise for the pupil to repeat all the mistakes of the race, to experience all its blind gropings after truth, and to work problems with crude methods and poor notation when more effective ones might equally well be given him. The only possible argument for this procedure is that the pupil by following it gains the power, which comes only by struggle. This argument is refuted by the fact that enough of struggle can be obtained by attacking problems in the easiest ways and by the most effective methods, and that in the latter case the pupil gains not only power from the struggle, but the joy of a wider conquest.

Some examples in which school curricula rightfully violate the historical order are:

1) The teaching of the Hindoo numeral system before the earlier system of the Romans, and the entire omission from our curricula of the still earlier system of the Greeks.

2) The handling of fractions by reducing them to a common denominator rather than to fractions with unit numerators, as was done by the Egyptians and Greeks; or to fractions whose denominators are 12 or 60, as was the practice of the Romans.

3) The very early use of decimal fractions, when they are, in point of development, the very last topic of our ordinary arithmetic.

4) The use of Cartesian and other co-ordinates in the study

of conic sections instead of the purely geometrical methods by which their properties were discovered.

In view of the above facts, it may be fair to ask if the history of mathematics does really shed any light upon the order of topics in the mathematical curriculum. In spite of the above list of contrary cases, the answer must still be affirmative. If we examine the above list, we see that in all cases considered, the idea developed in the later time, which now has an early place in the curriculum, is in every case a new method of expressing concepts already familiar. The concept of a number is the same whether the number is written in Greek, Roman, or Hindoo numerals. Writing the number in Hindoo numerals gives greater power in computation, but in no way changes the concept or the difficulty of apprehending it. The same may be said of fractions, whether common or decimal. The concept is the same and the modern method of treatment is easier and more powerful. Co-ordinate geometry does contain some concepts not distinctly stated by the Greeks, but they are easily mastered and make the entire treatment of conic sections much easier than the methods of the ancients.

If now we exclude from consideration those matters which are dependent upon a good notation, i. e. upon suitable tools to work with, we should expect that mathematics would begin with those concepts which are the easiest and of the most practical importance to man and proceed gradually to those which are more difficult and more remote from his daily needs. As this also seems the most natural and sensible method to pursue with the individual pupil, the order of historical development ought to have considerable bearing upon that of the curriculum.

We will now set to work to find from the history of mathematics what topics are the easiest and most closely connected with human interests. For this purpose a study of the development of mathematics by races, rather than that of the science as a whole, is necessary. By studying the development in as many races as have produced a science of mathematics and by comparing these results, we may hope to find an approximately accurate sequence of topics in respect to their ease and interest.

The first nation to develop a considerable body of mathematical knowledge was the Egyptians. The Ahmes papyrus shows that as early as 1700 B. C.—and probably 700 years earlier—the

Egyptians possessed considerable knowledge of arithmetic, geometry and algebra. Their arithmetic included operations with both whole numbers and fractions, a large portion of Ahmes's work being given to the latter. The geometry was wholly of the empirical kind and gave rules for finding the areas of fields of various shapes, including circular ones, for finding the contents of barns of certain shapes, and some computations on pyramids. The algebra consists of problems concerning an unknown Hau, or heap, which do not differ much from many of our problems in simple equations.

The Babylonians developed considerable mathematics contemporaneously with the Egyptians. Astronomy seems to have been their starting point. They divided the year into 360 days and the circle into 360 degrees, formed an extensive number system with 60 as the base, and attained some geometrical proficiency. We find no trace of algebra among them.

The Greeks early acquired all the mathematical knowledge of the Egyptians. They developed the Egyptian arithmetic into a system of every day reckoning, *Logistic*, and a quite elaborate theory of numbers, *Arithmetic*. The empirical geometry of the Egyptians, they at once based upon a deductive reasoning, and gradually extended its limits and reduced its assumptions until in the hands of Euclid, it took the shape we know it at the present day. Appolonius in his great work on conic sections treats of matters now reserved for college courses and discovered practically all the properties of conic sections without the aid of the powerful modern methods of analysis.

The Greeks for many centuries left the algebra of the Egyptians entirely unchanged. The reason for this is partly the tendency of the Greek to see everything as a form, even their propositions on the theory of numbers being worked out with geometrical representations of the numbers; and partly that in their method of writing numbers all the letters of the alphabet were used to represent particular numbers and no characters were at hand for the representation of general numbers. Under this handicap the wonder is not that the Greeks produced no algebra for so many centuries, but that Diophantus in the 4th century was able to produce so much algebra as he did.

We now turn our attention to the Hindoos. We find that the earliest of their mathematical writings, which have come down to

us, those of Arya-Bhata, treat of arithmetic, algebra, geometry, and plane trigonometry. The Hindoos developed in early times the numeral system which is now in universal use. Their arithmetic prospered under it; and the letters of their alphabet being thus freed from having to represent particular numbers could be used for general number. The Hindoo, Bhaskara, made great use of this possibility in the 12th century. His algebra contains solutions of simple equations with one and two unknowns and rules for the solution of some quadratic equations. The Hindoo geometry, however, fell far short of their algebra. Bramagupta (660 A. D.) proved the pythagorean theorem and a few other propositions. Later Hindoo mathematicians seem to have acquired through the Arabs a knowledge of Greek geometry but to have made no discoveries themselves.

The Arabs, while possessing a great body of mathematical knowledge, were not great originators. When they were first stirred to intellectual activity by the ardor of a religious enthusiasm, they found themselves between two highly cultivated races, the Hindoos and the Greeks, and they also found it much easier to acquire the knowledge and science of their neighbors than to originate their own. They seem to have mastered the works of the Hindoos down to and including Bramagupta by the end of the 8th century, and those of Greek geometry by the end of the 9th. The arithmetic and algebra of the Hindoos proved more congenial to the Arab mind than the geometry of the Greeks, and they advanced the former sciences far beyond their Hindoo masters. They made, however, little or no contribution to geometry.

The mathematics of the Chinese, while entirely isolated from those currents of thought which have influenced European mathematics, throws some light upon our problem. At a very early period (1000 B. C.?) the Chinese were acquainted with several geometrical or rather architectural tools, such as the rule, square, compass, and level. They were also familiar with a few geometrical theorems. They had an arithmetic which was decimal in notation, but they seem to have been able to do little more than to calculate by the aid of the swan-pan. Their mathametics seems to have stayed for a long time in approximately this state, and to have advanced out of it only with the aid of outside influences such as those of Buddist or Mohammedan missionaries in the 13th century.

From the above we see that every race to develop a considerable body of mathematical knowledge has begun with simple arithmetic and geometry. In the case of the Egyptians and the Hindoos algebra also appeared before any considerable advance was made in the other two. The Greeks advanced geometry and arithmetic through geometrical means to a high state of perfection; but on account of their unfortunate number system made no progress in algebra. The Hindoos carried the three along together, their arithmetic and algebra leading their geometry. When the Arabs became the leaders in the mathematical world, they took the algebra of the Hindoos and the geometry of the Greeks and put them together to the advantage of algebra. They worked out the general solution of the quadratic equation (with real positive roots), justified the process on geometrical grounds, and found geometrical solutions to a large class of cubic equations.

The changes introduced into algebra since the Arabs are: 1) a greatly improved notation; and 2) the new concepts of negative and imaginary numbers. I have shown in another paper that the discovery of the nature of these numbers was first made by geometrical means, and that their clearest explanation is still through geometry.

We see now that arithmetic, geometry, and algebra arose at practically the same stage of civilization and have advanced in close contact, constantly receiving and giving aid to each other. Geometry has been the largest giver. Without it, arithmetic and algebra would probably never have their present position. We must therefore conclude that what has always been joined together in the development of the subject ought not to be put asunder in its teaching.

At no time is the proper joining together of the subjects of more importance than in the years when the pupil is first getting hold of the abstract ideas of algebra. Then, if ever, he needs those areas and measurements, which made plain to the first algebraists the meaning of their results and assured them of the correctness of their processes. To teach algebra in the first year of the high school with no background of geometry and no accompanying study of those geometrical truths which were of such service to the discoverers of algebra, seems utterly contrary to the teachings of the history of mathematics.

THE TEACHING OF GEOMETRY.

By Miss Clara A. Hart.

Wadleigh High School, New York City.

[continued from the november number.]

By such exercises as these the imagination is quickened and to the pleasure of discovery is added the conviction in the student that he has capacity for the work, a conviction whose value cannot be overestimated. After a number of other exercises the student will soon be ready for more difficult propositions, the order of which should be arranged so as to provide a logical development. Miscellaneous exercises are extremely valuable for review, but for the beginner, exercises should be given which bear directly upon a theorem just demonstrated. After several of these to fix the new idea, more complex exercises should be given involving a review and combination of earlier principles; and at the close of every book a large number of miscellaneous exercises should be given to serve as review work and also as valuable practice in classification and generalization.

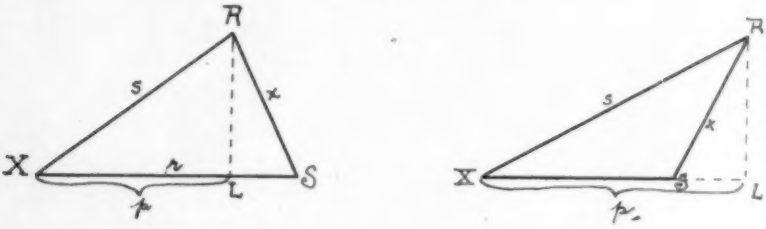
Failure to solve exercises is often due to the overlooking of the *hypothesis*. Students look for the goal before they have even examined the conditions which lead to it. Again, the careless drawing of figures and the lack of generalization in them are often great stumbling blocks.

Breadth of view should be aimed for always, and its development may be greatly aided by generalization and by suggestions of continuity; thus when a student discusses the proposition: "The bisector of any angle of a triangle divides the opposite side into segments proportional to the other two sides," why should he make a separate proposition regarding the bisector of an exterior angle? If he generalizes the first case, will he not get a much clearer conception of what is meant by segments of a line?

The idea thus assimilated will be of service in attacking such a proposition as, "If two chords intersect within a circle the product of the segments of one is equal to the product of the segments of the other, and extending it to the case of two secants or of a tangent and a secant?

A very valuable exercise is the translation into words of a formula which has been obtained by proof; thus in finding a value

for the square of the side opposite an acute angle of any triangle it is a waste of time for the student to attempt to state the theorem before giving the proof and he is robbed of the opportunity to formulate in words an exact equivalent of symbolism. So many text-books give the proof of this proposition as if the chief aim were to mystify the student, that it may not be amiss to outline here what seems to be the natural method.



A value for x^2, the square of the side opposite an acute angle of a triangle is sought, in terms of the other two sides and the projection of one of them upon the other.

$x^2 = \overline{RL}^2 + \overline{LS}^2$

Finding known values for $\overline{RL}^2$ and $\overline{LS}^2$

$\overline{RL}^2 = s^2 - p^2$

$\overline{LS}^2 = (r-p)^2$ or $(p-r)^2$ Substituting

$x^2 = s^2 - p^2 + r^2 - 2rp + p^2$

or $x^2 = s^2 - 2rp + r^2$

Translating into words. The square . . . . etc.

Instead of giving the student the opportunity to think out his own method, many a teacher of abundant power will *explain* slowly and carefully such a problem as, "upon a straight line to construct a segment capable of containing a given angle." Of what value is the mental discipline thus attained compared with the power developed by securing an original method from the student? If he has been directed in such a case to imagine the problem solved and then to study the figure to see how far he may construct it, he will rarely fail to find some more simple solution (usually the one indicated in Figs. 6 or 7) than the conventional treatment of the text book.

Of course this problem should be given immediately after discussing the measurement of the inscribed angle. It is amusing

to observe the preference which the student will show for his own method of proof.

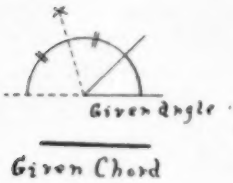


Fig. 6.

Fig. 7.

It has been objected that geometry admits of little classification and that little application of *method* is possible in its attainment. There would be little ground for this objection if the subject matter were properly handled. As the student progresses in his work he can readily learn to classify exercises and to select from a not overwhelming number of methods which he has been called upon to master, the one which applies best to the case in hand. Thus, whenever a converse proposition is called for the *indirect* method of proof will suggest itself. When four lines are to be proved proportional, the student may seek to prove two triangles similar, each triangle containing two of the four lines under consideration. Very simple exercises will soon develop the ability to master others far more complex. Thus, for example, after proving that "two triangles are similar if they are mutually equiangular," the following figures may be presented for discussion, the questions asked by the teacher being merely,

Fig. 8

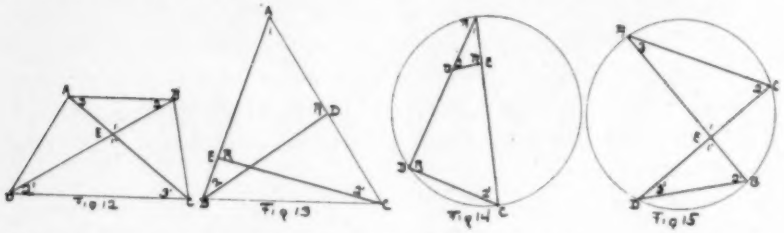
Fig. 9

Fig. 10

Fig. 11

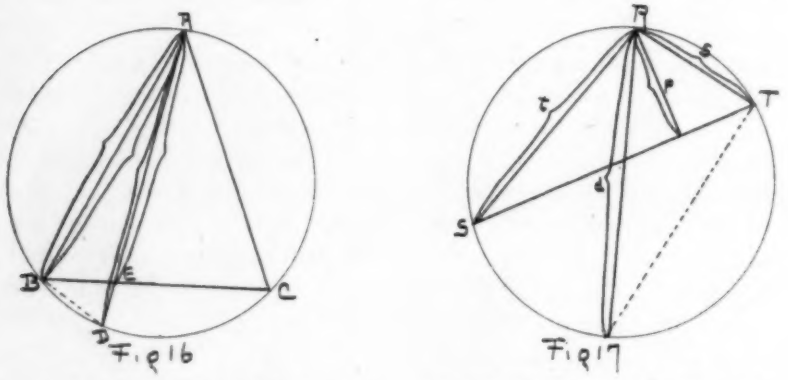
"Can you find similar triangles in these figures?" Equal angles will at once be noted and if marked with numbers as found will serve to locate homologous sides, thus:

Proportional lines may now be found in each figure. Again, consider the following exercises: Calling for the establishment



of the proportion: AE:AB::AB:AD, and the equation $ts=dp$ respectively.

If the student marks the four lines under discussion as here indicated, he can hardly fail to see that the construction of BD



and of TL in figures 16 and 17 respectively will give him triangles that may be proved simliar and that by proving the triangles similar the required proportionalities may be established.

After proving that "If from a point without a circle a tangent and a secant be drawn, the tangent is a mean proportional between the whole secant and its external segment," how many teachers strike while the iron is hot by putting the student to work at once to find a mean proportional between two lines, guiding him if necessary to perceive that one line may be used as the whole secant and the other as its external segment.

Numerical applications are extremely important in geometry, both because young students usually like them and because they give a hold to those students who lack imagination. It is often made evident by such exercises that many of the students have

not really appreciated the significance of a theorem. A teacher with a breadth of view and a knowledge of the natural sciences may infuse a new interest by giving simple problems in astronomy, physics, etc., as applications of theorems. The difficulty here seems to be that most teachers of mathematics are lovers of the pure science and themselves but slightly interested in its utility. On the other hand, most students enjoy the applications and especially the correlation with subjects of which they know something. They do not readily develop the power to apply the knowledge which they have acquired unless they are led to do so while it is nascent.

An introduction of the elements of logic at a very early stage in the study of geometry is invaluable. It adds to the student's equipment, which is usually very meager. It also serves to dispel the conviction frequently encountered in beginners that the reasoning of geometry is quite distinct from all other kinds of reasoning in mathematics and indeed from that of common sense.

A student after a few days instruction in geometry by the writer in attempting a demonstration administered an unconscious rebuke to the instruction by saying naively, in stating a hypothesis, "Let AB be a straight line (we *know* that it isn't, but just pretend that it is, and we'll prove it)." She admitted when questioned that geometry seemed to her to be a good deal of a hood-winking process.

One of the difficulties in securing good results in geometry in the secondary schools is the absolutely new point of view which it offers to many of the students. There is too sudden a transition both in method and in subject matter, with too limited a period of time to admit a preliminary course. Now this difficulty is obviated in many schools by the concrete or inventional geometry which is offered in the grades. But this work is rarely undertaken with the skill necessary to produce the best results. As yet results are indefinite and a standard is lacking for teachers. The movement to include algebra and geometry in grade work has sometimes led to extremes, and the pupils have gone to high school with as exaggerated a notion of their knowledge of these subjects as that knowledge is superficial. The development of the work in the high school is thus robbed of its freshness and the pupils feel that they are not

progressing as they should from strength to strength.

The effect is not happy if the student is required to repeat the work. It were better for him to have at least the pleasure of newness of work instead of a worn off interest. The work of the grades should leave that impression of partial mastery which incites to new effort.

When our Normal and Training schools for teachers awaken to the desirability of adopting some such syllabus as Prof. John Perry of the Royal College of Science of London has suggested we may hope for better results in the teaching of elementary mathematics. This syllabus is given in detail in the Educational Review (English), Oct. 22, 1901. The following abstract may give an idea of its scope: "Use of squared paper by merchants and others to show at a glance the rise and fall of prices, temperatures, of the tide, etc. The use of squared paper should be illustrated by the working of many kinds of exercises, but it should be pointed out that there is a general idea underlying all. The following may be mentioned. Plotting of statistics of any kind of special or general interest, what such curves touch, rates of increase."

"Mensuration. Testing experimentally the rule for the length of the circumference of a circle, using string around cylinders or by rolling a disc or sphere. Methods of measuring the lengths of curves. Testing the rule for the areas of a triangle, a rectangle, a parallelogram, a circle, an ellipse, the surface of cylinder, the surface of cone, etc., using scale and squared paper. Propositions in Euclid relating to areas tested by squared paper, also by arithmetical work on actual line and angle measurements. The determination of the areas of irregular plane figures, (1) by using the planimeter, (2) by using Simpson's or other well known rules for the case where a number of equiordinates or widths are given, (3) by using squared paper, and when equidistant ordinates are not given finding such ordinates," etc.

"The straight line, meaning of its slope, slope of a curve at any point in it. Rates of increase, illustrated by the speed of a body. Easy exercises on rates of increase of y with regard to x in the case of $y=ax^n$, with illustrations from mechanics and physics."

The writer visited some of the elementary schools of Cam-

bridge and saw some excellent work in concrete geometry done by practice teachers from the Cambridge Training School. It consisted mainly of the careful drawing of plane figures with ruler and protractor, estimation of measurements and heights by scale. In this kind of work no rigorous demonstrations are given at first, but simple relations are deduced from measurements and observation. Many valuable suggestions are offered in the little book, "Geometry in the Grammar Grades," by Prof. Hanns of Harvard. "Sundara Row's Geometric Paper Folding" also gives good hints. Such work may be given as cutting a proper parallelogram along a diagonal and showing by superposition that the diagonal of a parallelogram divides it into two equal triangles. A frame made of four wires jointed at the ends to move easily will impress the fact that four sides do not determine a quadrilateral. Three wires similarly joined will show the case of the triangle. The ideas gained by this kind of work must be *used* to enlarge experience. The mind must be alert to apply facts as soon as acquired. Thus the student may be taught to measure the length of a pond by triangulation, and the heights of buildings may be obtained. Field work may furnish many interesting problems. Lacroix says of geometry, "It seems to me a subject well adapted to interest children, provided it is presented to them chiefly with respect to its applications. The operations of drawing and measuring cannot fail to be pleasant, leading them as by the hand to the science of reasoning," and Rousseau reminds us that we seem not to comprehend that their (children's) method is not ours and that what should be for us the art of reasoning should be for them merely the art of seeing. Instead of thrusting our method upon them we would do better to adopt theirs. * * * For my pupils geometry is merely the art of handling the ruler and compasses." There is sometimes danger in leading up to more difficult work. Emphasis must be given to the fact that no statement is true because a figure makes it appear so. There must be a clear distinction made between axioms, postulates, definitions and theorems, and every statement in a proof must be based upon one of these. The foundations for a structure of Reason must be sure.

At the present time in the teaching of geometry in most American secondary schools it is impossible to presuppose a

course of anything like the scope outlined for preliminary work in this paper.

The ground covered in most good schools does not vary to a great extent, although the method of covering it is by no means uniform. The majority take up some text-book, require students to give proofs following more or less closely the proofs given therein, and to supplement this work with a variable number of original exercises. In some schools the theorems are dictated and the student is required to develop a proof. This, however, is done but rarely, as is determined by the time element. In many schools, as in the Springfield and Ithaca high schools, a syllabus is used and excellent results are obtained.

It seems to be unimportant which of these methods is followed. In the hands of a good teacher there is little danger that the students become slaves to the text. If the recitation is conducted as it should be, memorizing must soon be found worse than useless. A good text-book serves as a model and saves time, especially in a hasty review.

It seems probable that something will soon be done to unify secondary mathematics in this country. In Germany students from eleven years of age carry parallel courses in alegbra and geometry for five years continuously (see Young's "Teaching of Mathematics in the Higher Schools of Prussia"), and in England algebra, mechanics and geometry run side by side. A teacher in one of the London schools expressed to the writer amazement at the separation of these subjects in America, saying, "What, in the meanwhile, do you do with the students who don't take to geometry? With us they can at least be interested in algebra or mechanics."

The work of Prof. John Perry and of many others, both in Germany and in this country, is resulting in a vigorous movement toward further unification, toward a far broader selection of mathematical material and toward the correlation of mathematics with science.

Lagrange has said, "As long as algebra and geometry traveled separate paths their advance was slow and their applications limited. But when these two sciences joined company they drew from each other fresh vitality and thenceforward marched on at a rapid pace toward perfection." Prof. Moore in discussing secondary school mathematics before the American Mathemati-

cal Society, said, "Would it not be possible to organize the algebra, geometry and physics of the secondary school into a thoroughly coherent four years course, comparable in strength and closeness of structure with the four years course in Latin? (Here under physics I include astronomy and the more mathematical and physical parts of physiography.)" (Bull. Math. Soc., May, 1903.)

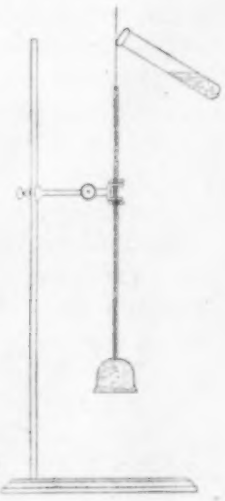
Work along these lines is finding active development in Chicago and in other western cities. Discussions of this work are appearing in the Mathematical Supplement of School Science from April, 1903. As suggested at the beginning of this article, the strongest impetus to reform must come from the colleges, not only in their requirements for admission, but in the liberality of the courses offered by them, so that secondary teachers may obtain training in the pedagogy of mathematics according to the laboratory system. There would thus be a greater unity of aim between the secondary and higher institutions, which should lead to far better results than have been thus far attained.

FILLING A THISTLE-TUBE TO ILLUSTRATE OSMOSE.

J. A Giffin

St. Catherines, Ontario, Can.

After the animal membrane is tied or sealed to the funnel of the thistle-tube it may be quickly filled. Place the thistle-tube in a clamp of a retort stand as in the accompanying figure. Insert a straight piece of iron wire about 10 inches long into the neck of the tube so that the wire will extend about two inches into the tube. Place a test-tube, containing some of the solution, in the position shown and pour the solution slowly down the wire.



CORRELATION OF MATHEMATICS WITH BIOGRAPHY, HISTORY AND LITERATURE.*

By Jos. V. Collins.

Stevens Point, Wis.

[CONTINUED FROM THE NOVEMBER NUMBER.]

The English statesman Gladstone, graduated at Christ Church College, Oxford, taking a double first in the classics and mathematics, the highest test of scholarship known to the university. Anyone who knows anything about the English universities knows that extraordinary ability in mathematics was required to win such a standing, though, of course, Cambridge carries the greater reputation in mathematics.

Turning from statesmen to such a person, for instance, as Henry Ward Beecher, we are not disappointed in expecting to find something entertaining concerning his mathematical education.

He was taught mathematics at Mt. Pleasant Preparatory School by W. P. Fitzgerald. Says Beecher: "He taught me to conquer in studying. There is a very hour in which a young nature, tugging, discouraged, and weary with books, rises with the consciousness of victorious power into masterhood. For ever after he knows that he can learn anything if he pleases. It is a distinct, intellectual 'conversion.'

"I first went to the blackboard, uncertain, soft, full of whimpering. 'THAT LESSON MUST BE LEARNED,' he said in a very quiet tone, but with a terrible intensity and with the certainty of fate. All explanations and excuses he trod under foot with utter scornfulness. 'I want that problem; I don't want any reason why you don't get it.'

" 'I did study it two hours.'

" 'That's nothing to me: I want the lesson. You need not study it at all, or you may study it ten hours—just to suit yourself. I want the lesson. Underwood, go to the blackboard.'

" 'Oh, yes, but Underwood got somebody to *show* him his lessons.'

" 'What do I care how you get it? That's your business. But you must have it.'

---

*ERRATA. Omit line 7 top of page 641 and insert it as line 4 top of page 642. On page 643 place the paragraph beginning: It is quite . . . . immediately after the second letter.

"It was tough for a green boy, but it seasoned him. In less than a month I had the most intense sense of intellectual independence and courage to defend my recitations.

"In the midst of a recitation, his cold and calm voice fell upon me, *'No!'* I hesitated, stopped, and then went back to the beginning, and, on reaching the same spot again *'No!'* uttered with a tone of perfect conviction, barred my progress. 'The next!' And I sat down in red confusion. He, too, was stopped with 'No!' but went right on, finished, and as he sat down, was rewarded with, 'Very well.'

" 'Why,' whimpered I, 'I recited it just as he did, and you said 'No.'

" 'Why didn't you say *'Yes,'* and stick to it? It is not enough to know your lesson. You must *know* that you know it. You have learned nothing till you are *sure*. If all the world says 'No,' your business is to say *'Yes,'* and to *prove* it.' "

Beecher was said to have attributed much of his subsequent habit of steady unantagonistic defence of his opinions to this early mathematical training. Was it this training that aided him when he faced the Liverpool mob? "I had acquired by the Latin and mathematics the power of study," Beecher says, "and I turned it upon things I wanted to know." It was said of Beecher that he had the choice when in college of either taking high rank in his studies or of giving most of his energies to private study in fields in which he was interested. Beecher chose the latter. The same thing was true of the poet Lowell.[7]

Benjamin Franklin as a boy in the Boston Garmmar School failed in the study of arithmetic. Later, grown stronger in mental power, through shame of his failure, he was led to take up the study by himself of a work on arithmetic which he now read with ease. Franklin studied a work on navigation and acquired a knowledge of the little geometry it contained. Strangely enough Franklin may be classed as a mathematician through his interest in one of the most curious fields in the whole realm of mathematics, viz., that of magic squares. That Franklin had ability amounting to genius in mathematics is proved by what he actually accomplished in magic squares as shown by his published works.

---

7 Biography of Beecher by his son and son-in-law, Wm. C. Beecher and Rev. Samuel Scoville, pp. 94, 113.

The boy Edison had only two months' schooling all told. His mother had been a school teacher and she taught him to read. Before he was ten, it is said he had read Hume, Gibbon, and other standard authors. Nearly all of his biographers say he read Newton's Principia, but they assign different years, all the way from seven to twelve. Some say he acquired a dislike for mathematics from reading the principia. On this point the writer had the following from Mr. Edison:

Orange, New Jersey, April 14, 04.

Dear Sir:

Replying to yours of the 22d ult., I beg to state that the statement about my reading Newton's Principia while still a boy is not correct. Yours truly,

THOMAS A. EDISON.

The following paragraph is instructive as showing Mr. Edison's mathematical ability. "I once asked Mr. Edison how he made his calculations. The answer was: 'I don't know exactly: but I can't do them on paper. I have to be moving around.'" That he does them efficiently, however, is shown by the results. I have also in mind this moment the incident of a well-known physicist of my acquaintance, a man of high scientific rank and rare mathematical attainments, who had done an immense amount of figuring on some point which he mentioned to Edison, without being able to reach a satisfactory conclusion. Edison, at once, though having only a few minutes for consideration, gave him the result and convinced him of its accuracy, much to his surprise and admiration.[8]

When Galileo was a boy his father would not let him study mathematics, claiming it was useless. When a young man of twenty studying medicine at Pisa, he once had the opportunity of listening outside the door to a lesson in Euclid. He was captivated with the study and later took it up secretly. At twenty-six he accepted a chair of mathematics at Pisa, and later held the same chair at Padua. Thus it appears to have been the geometry which swerved him from medicine to mathematics, and later to physics where he made his great discoveries.

References in literature to mathematics can be quite as in-

8 G. P. Lathrop, Harper's Magazine, Feb. 1890.

teresting as biographical notes. We will take space here for but a single one, viz., that in Wordsworth's Prelude where he speaks of geometry.

> Yet may we not entirely overlook
> The pleasure gathered from the rudiments
> Of geometric science. Though advanced
> In these enquiries, with regret I speak
> No farther than the threshold, there I found
> Both elevation and composed delight:
> . . . . . .
> More frequently from the same source I drew
> A pleasure quiet and profound, a sense
> Of permanent and universal sway,
> And paramount belief: there, recognized
> A type, for finite natures, of the one
> Supreme existence, the surpassing life
> Which to the boundaries of space and time
> Of melancholy space and doleful time
> Superior and incapable of change,
> Not touched by welterings of passions—is,
> And hath the name of God
> . . . . . .
> Mighty is the charm
> Of those abstractions to a mind beset
> With images and haunted by herself,
> And specially delightful unto me
> Was that clear synthesis built up aloft
> So gracefully: . . . . . .
> In verity an independent world,
> Created out of pure intelligence.

It might be supposed that the writer had selected only certain characters in history known by him to have had some special ability in mathematics, but such was not the case. One is almost sure to find something interesting in the mathematical education of almost any eminent person, whatever the field he has gained his reputation in. Of course, not all eminent men are so greatly indebted to their mathematical training for subsequent success as some of those mentioned above. Some have put themselves on record as thoroughly disliking and disgusted

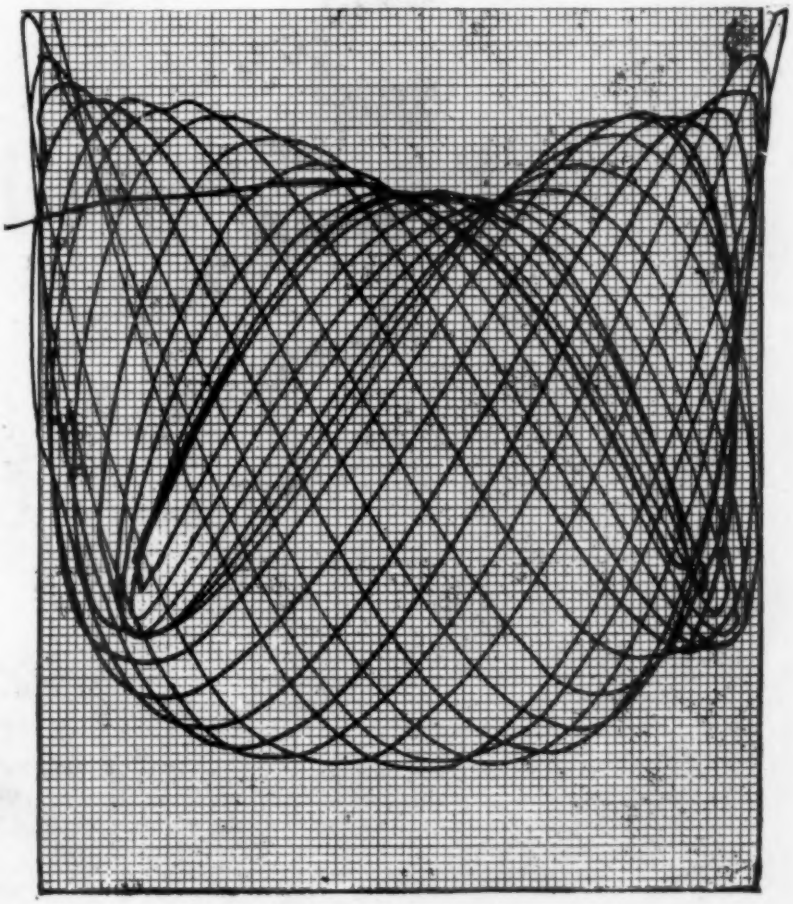
with the subject. Macaulay is a notable example. But in not a few instances (in Macaulay's case, in fact) the mathematics itself was at fault in the way it was taught, and not the dissatisfied learner. As another instance one can quote a remark of Greeley's: "Yet I am thankful that algebra had not yet been thrust in our rural common school course to knot the brains and squander the time of those who should have been learning something of positive and practical value." No one who has ever examined the text-books of algebra in Greeley's time can doubt that he was not far from right in his judgment.

Once interested in such historical topics it is easy to find an abundance of materials in histories of mathematics like Ball's and Cajori's. The story of Egyptian mathematics with the curious relations about the pyramids, the story of Thales work and of his elation being so great over inscribing a right triangle in a circle that he sacrificed an ox to the immortal gods, the story of Pythagoras and the Pythagoreans with their five-pointed star as fraternity emblem, the stories connected with the duplication of the cube, the *a priori* reasoning which led the Greeks on in trying to square the circle, the story of the inscription over Plato's door, the story of Ptolemy, Euclid, and the royal road to geometry, the saying about the probable occupation of the deity, and, in later times of Haroun al Raschid's interest in science and mathematics, of Mohammed's signature with his scimitar in the sand, the story of the public contests in solving problems in the thirteenth century, and of Frederick Barbarossa's interest in them, the story of Cardan's theft, the stories connected with the invention of the symbols of algebra, etc., etc., will all fit some occasion giving temporary relief to the possible tedium of the recitation, and, at the same time, add zest to the study.

A NEW METHOD OF PRODUCING LISSAJOU'S FIGURES.

By L. V. Case.
Tarrytown, N. Y.

Apparatus consists of a pair of chains joined by a clamp of peculiar construction which admits a quick change, yet holds the two chains securely fixed at any desired position. A heavy pendulum bob with a vertical hole passing through the centre, through which freely slides a stylus filled with ink. The bob is supported by a string fastened at a point midway between the two chains and passing through the clamp in such a manner



as to readily admit of a quick adjustment of the length of the pendulum. When the pendulums are oscillated, a complete harmonic curve is traced in ink on the note-book paper. Giving a point the value of ONE and a loop TWO, the length of the pendulums will vary inversely as the squares of the values of any two adjacent sides.

In this method the following difficulties peculiar to the Blackbourn have been eliminated.

1. The varying lengths of the pendulums as the sand runs out and lessens the weight of the bob.

2. The broad temporary record of sand.

3. The shortening of the lower pendulum as the two strings are fastened higher up.

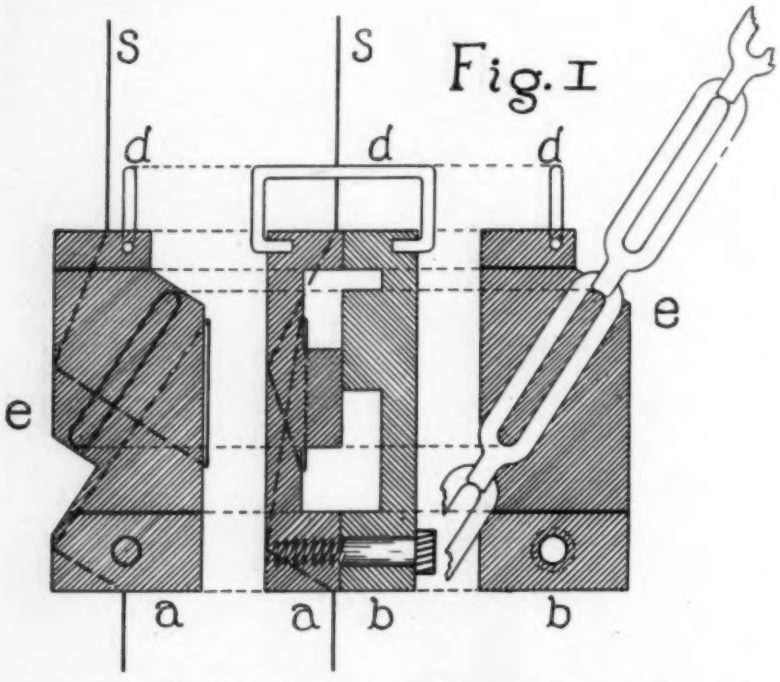


Fig. 1

4. The difficulty of tying a knot that will not slip as the heavy bob oscillates.

5. If the knot is sufficiently firm to prevent the slipping, the resulting difficulty of untying the knot to vary the length of the pendulums.

The first difficulty is overcome by not having the weight of

the tracing stylus supported by the bob, but resting its whole weight on the paper and its slight and constant resistance due to friction of the smooth glass stylus on the paper being practically a negligible quantity.

The second difficulty being overcome by using a stylus of glass filled with ink that leaves a fine permanent line on the paper that may be filed in the note-book without further modification.

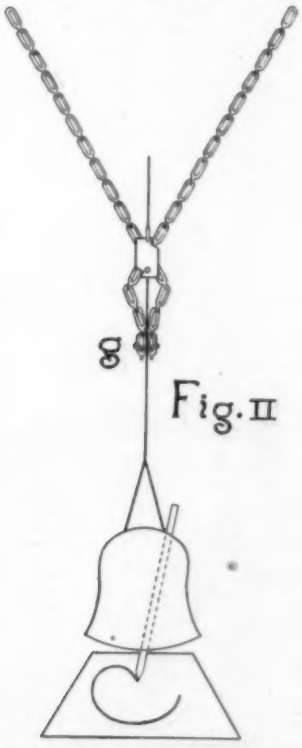


Fig. II

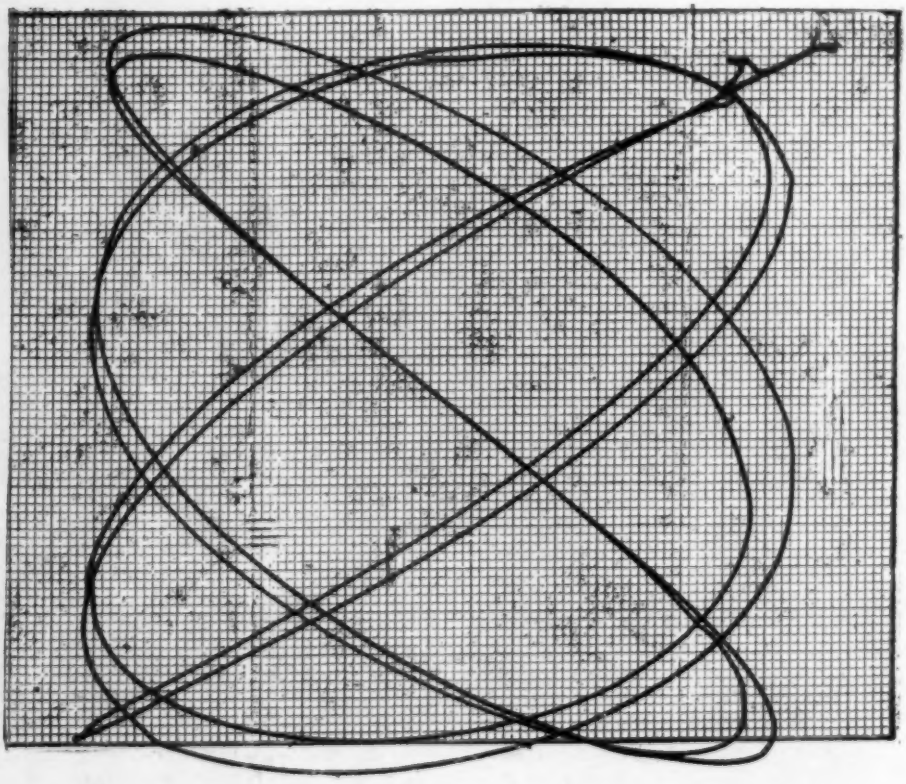
The third difficulty is overcome by having the bob supported by a central string and not by the two joined together; the latter only serving as a guide for the length of the shorter pendulum.

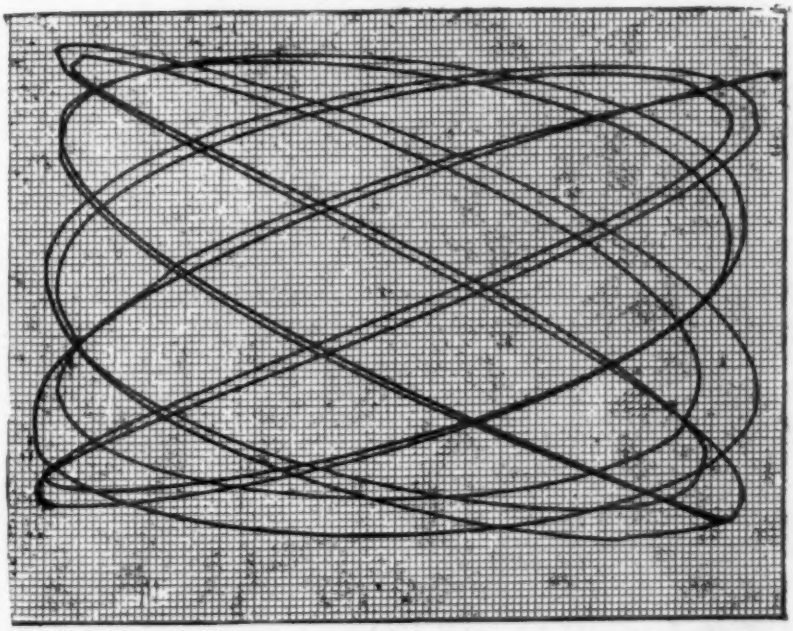
The fourth and fifth difficulties are obviated by substituting light chains for the strings, and a clamp of peculiar construction that allows the links to be readily fastened or unfastened at any desired point.

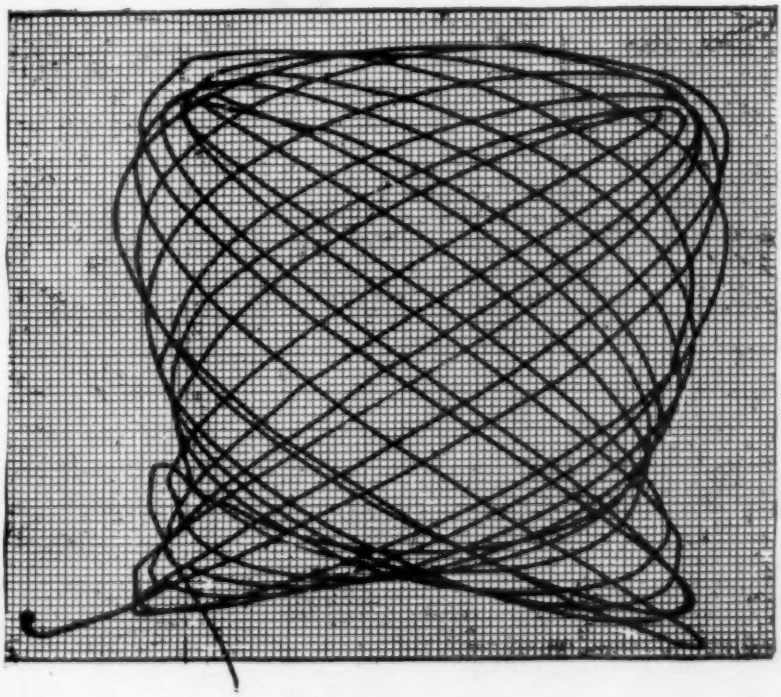
The bob is composed of lead and weighs about four kgs. The hole is made at a slant so that the stylus will not interfere with the supporters, and so that the point of the stylus will be in line

with the supporting line of the bob. The stylus is made of glass tubing of 4mm. bore drawn to a point smelted off and the tip ground back until there is a capillary opening. The stylus should move freely in the bob. The string supporting the bob is made of braided silk fish line. The clamp is composed of four pieces. The two sides (a and b) being held together by the screw (c) at one end and the clamp of No. 10 spring brass wire (d) at the other.

Both (a and b) have projections (e) that fit into the links of the chain. The screw passes through a hole in (b) with threads in (a). The string (s) passes through (a) with a loop. The complete clamp weighs 20gms. The chain is of aluminum of the form shown in Fig. 1, and the free ends held by a rubber band (g) in Fig. 2.







REPORT OF COMMITTEE ON COURSE OF STUDY IN ZOOLOGY AND BOTANY.

The committee appointed at the meeting of Nov. 1904 to consider and report upon the course of study in Zoology and Botany for secondary schools desire to report substantial agreement upon the following recommendations. The Committee has not thought that it was expected to report upon the content of the course, but rather upon the method and scope of the work. As the members of the committee were widely scattered this report is based upon correspondence and will take up the subject by topics as they were discussed in the correspondence.

1. The Committee is practically unanimous (one member dissenting in part) in the belief that an entire year should be given to either Zoology or Botany, whether only one is offered in the course or both are offered as electives. A half year course does not give time for adequate presentation of either subject. The fundamental principles of Biology are to be found in both Botany and Zoology and it is not necessary to present both subjects in order to give to the pupils a conception of the fundamental life processes.

A suggestion has been made that where only Zoology can be offered in the course a few lessons should be given to plant studies, such as the study of plant cells, of chloroplasts and starch, and perhaps the flower. This would give a conception of the place of plants in life and broaden the view of the pupil.

Likewise it has been suggested that the field study of birds should be given in whole year Botany courses. The birds are closely associated with plants in a twofold way. The plants furnish food for the birds by their seeds and fruits, while the birds protect plants from the ravages of harmful insects. It would give Botany pupils an interest in animals and their relations to plants.

2. It is the opinion of the Committee that in Zoology the subject should be developed along the lines of evolution or what is known as the "logical order", but that the teacher should feel free to depart from this order of study for the purpose of making field studies or live studies at opportune times when the conditions are right. Such studies need not detract from the general development of the subject as a whole and may be recalled for

more formal study when reached in regular course. It is felt that there should be a consistent plan which shall develop the subject in the minds of the pupils logically. The order of evolution is the most natural order and should form the backbone of the course.

In Botany the case is somewhat different. The course divides itself easily into two parts. In one part we have the study of groups in their systematic relation from the lowest to the highest or the order of evolution, bringing out clearly the relations and diversity of the groups. In the other part there is the study of a single great group of plants, the seed plants. These two parts may each easily occupy a half year and most teachers have found it convenient to divide the course in this way. Many teachers prefer to reverse the order and study the flowering plants in the first half year and give the systematic study by groups in the last half year. This gives a consistent course and is quite satisfactory, except that the wild flower studies under this plan would come in the winter and a rearrangement is necessary to bring that study into the spring term. With Botany as with Zoology the logical course beginning with the lower plants in the fall, but departing from the regular studies for short studies of materials in their season makes a good course and at the same time gives great opportunities for field work. We recommend that certain studies, such as the fall flowers, seeds and fruits, distribution of seeds, weeds, storage of foods, and preparation for winter and renewal of growth in the spring be included in the studies of the fall term in their season. These make excellent topics for field work and may well take the place of some of the morphological studies. Too much time is usually given to the study of lower types of plants. For secondary school, the seed plants with their great diversity and their close relation to every day life of the pupils offer a rich field of study full of interest to the pupil. The topics just mentioned with other economic topics that should be studied can well be given in this part of the course.

3. What is the relative value of morphology, physiology, ecology, and economics? The Committee believe that no one of these should dominate the course. Morphology as an end has no place in a secondary school course. It should be taught only so far as it is useful in interpreting the life and rank of the animal or plant. The keynote of the course should be,

"How does the animal or plant live?" "How does it solve it's problems of life"? Morphology, physiology, ecology, and economics have their mission in mutually helping to explain the life of the animal or plant. Just what their relative order or importance shall be will depend upon the particular study undertaken. Sometimes one phase of the work will be dominant, sometimes another, but all should work together for the one end, the life of the plant or animal. Sometimes field study is made too prominent. Field study has but little meaning and loses it's chief value when the other phases of the study are neglected. It has it's place as an important help in learning the life of the animal or plant.

4. How much, what and how should field study be done? Secondary school teachers are often urged to give more attention to field study, but the difficulties which surround such work are not always realized by those who confidently urge this phase of the work. There is no doubt of the advantage and interest added to the course by first-hand knowledge of the home life of living things, especially in secondary school work. But, large classes, rules of the School Boards, and interference with the work of other teachers are practically insurmountable difficulties in the way of making field work a class exercise. The best solution probably is in the double period plan. A class can be taken out during its regular period to nearby vacant lots or fields to make biological surveys. For most schools, however, the voluntary work of the pupils will give best results. There should always be some definite piece of field work outlined for the pupil to accomplish, with definite instructions as for any laboratory exercise. For teaching the field study habit, i. e. the habit of close observation of the life in the fields and a love for it, the birds and insects among animals and the wild flowers among plants offer the best opportunity. The enthusiasm of the pupils should be awakened in some manner if permanent results are to be obtained. This can be done very often by some device to stimulate competition. The field study of birds is being taken up with great success by many schools and the enthusiasm awakened is quite sure to be renewed with each migration season of the birds.

The study and naming of wild flowers always interests botany classes and much genuine enthusiasm can be awakened. There is a great need of simpler keys to the local floras based upon

easily recognized external characters. The key should be written especially for secondary school work and include the spring and late fall floras. A series of cheap colored pictures such as Mumford's pictures of birds would be a great help. High school pupils are too young and have too little time at their disposal to work out the names of wild flowers by means of keys of the sort now offered.

The collection of wild flowers has fallen into disfavor, but it could be made a useful and valuable feature of the spring work in Botany. The collection and mounting of the flowers and their parts as studied in the class could well take the place of drawings in the note books, but in all the study and collecting of wild flowers the pupils should not be allowed to uproot and destroy the plants. The flowers and leaf or branch must be made to answer in place of the entire plant usually insisted upon. Wild flowers are becoming all too scarce in the neighborhood of cities and towns. Collections of seeds, various woods and leaves are also interesting and profitable.

The management of insect studies and collections is more difficult. It is suggested that Riker mounts would help the work along. If the pupils were furnished the boxes ready for the insects, their enthusiasm in filling them could be easily awakened.

To sum up, there should be systematic plans for field studies by the pupils whether in Botany or Zoology. The pupils should become acquainted with the natural surroundings and life of as many as possible of the animals or plants they study.

5. The relation of animals and plants to man, the economic phase of the study of biology, is coming more and more into favor as a part of the well-balanced course in Zoology or Botany. It lends interest and a certain practical value to the work which is quickly recognized both by pupil and parent. In Zoology the economic relations of each group should be brought out in connection with the regular work. Some special studies of the relations of insects to man and other animals would be well worth while. In Botany, however, there is a much wider field for such studies, as for example, studies of trees and their woods, of stored foods, of medicinal plants, etc., and a larger proportion of time can profitably be set aside for this work. Such studies, however, should be subordinate parts of the course and not be allowed to interfere with the general plan of the course.

6. Physiology must always form an important part of any course, not a formal part, but a part necessary to the understanding of the life and behavior of living beings. In Botany an attempt should be made in all well planned courses to demonstrate by experiments, at least the principal functions of plants. Wherever practical this should be done by the pupils, either individually or collectively. In Zoology the fundamental functions of animal bodies should be developed as opportunities offer in the development of the course. It should not be neglected in any study but some studies offer better opportunities for teaching certain functions than others, and these may well be taken advantage of. But the physiology of the animal or plant should form an integral part of each study in such a way that the pupil will be absorbing a conception of the fundamental processes of life from the beginning to the end of the course.

7. The principle of evolution will form an important part of every course but not in any formal way. The place of each animal or plant studied in relation to others, and the development in complexity of the principal organs should form an incidental part of each study. The fundamental principles of evolution should be made clear by the use of examples as the work proceeds. Whether there should be any formal discussion of the doctrine of evolution and the various theories might well rest with the discretion of the teacher.

8. There are certain propositions which are now generally accepted by biology teachers. They will therefore be included in this report with only a brief statement.

Six periods per week should be the minimum amount of time given to Zoology or Botany with *at least* one double period for laboratory work.

Seven periods per week with two double periods of laboratory work per week would be the most satisfactory arrangement. With this amount of time at the disposal of the teacher, more care could be given to the development of the laboratory exercises Short periods tend toward hasty and ill-digested laboratory work. No greater demand upon the pupils time need result, for less home work would be required. We realize that high school pupils are crowded with work and are not advocating that the total demand upon them shall be increased by reason of increased laboratory requirements. In the case of half year courses, a still greater

allowance for the laboratory would be desirable to make up in part for the short course. An ideal arrangement for such courses would be five double periods per week with practically all the studying done in the laboratory.

The maximum number of pupils in a laboratory class should not exceed twenty-five. With large classes the teacher cannot give that personal attention that is demanded for successful work with high school pupils in a laboratory. The laboratory, if it means anything, means a chance for individual work and development as opposed to the machine like work demanded by large classes.

Living animals and plants should be used wherever possible and the use of dead material should be confined to those morphological studies which cannot be made with living material, and studies should be chosen with a view to the availability of living material.

There should be no dissection done by secondary pupils as a required class exercise. Whatever dissection is needed should be performed by the teacher in advance of the class exercise. The classes are too large and the pupils too young for such work. There is an abundance of work more profitable for the pupil, and it is a waste of time to require secondary school pupils to make dissections. Moreover the use of dissections should be restricted to as few studies as possible. The earthworm as a type of invertebrates and the frog as a type of vertebrates give all that is needed of such studies. Demonstrations and charts may be used for such studies of the internal organs of other animals as are desirable.

Morphological studies which require the use of high powers of the microscope should be minimized so far as possible. It will generally be better to use a projection instrument or even charts to demonstrate such parts. Projection instruments have a legitimate and profitable use in supplementing the regular work and for reviews. They may often take the place of the compound microscope in the study of microscopic preparations, but since they do not permit any initiative or individuality on the part of the pupils their use should be restricted for the most part to supplementing the other methods of study.

We urge that time be given for studies of Bacteria and sanitation, in both Zoology and Botany courses. In Zoology, the

study can be given with the Protozoa studies without much extra trouble or time In Botany, it can be given with the studies of Fungi where it naturally belongs. This topic is of very great importance from an economic standpoint and has good teaching values from the pedagogical viewpoint, but it does not fit into the evolution order very well and has heretofore been neglected. This is more especially true of the study of sanitation. It is coming to be recognized by educators that a subject which has such an important connection with human life should not be omitted from biology courses simply because it does not fit nicely into the groove of evolution.

We do not recommend extensive bacteriological studies. One lesson in growing a culture and sterilization processes and a lesson on the living bacteria will be sufficient if accompanied by some demonstrations of t he effect of heat, moisture and light which may be carried on by the teacher.

WORRALLO WHITNEY,
South Chicago High School, Chicago.
ELMA CHANDLER,
Elgin High School, Elgin, Ill.
AMELIA MCMINN,
West Side High School, Milwaukee, Wis.
ROUSSEAU MCCLELLAN,
Shortridge High School, Indianapolis, Ind.
T. L. HANKINSON,
State Normal School, Charleston, Ill.
FRED B. MAXWELL,
William McKinley High School, Chicago.
W. R. MITCHELL,
Hyde Park High School, Chicago.
GRANT SMITH,
Chicago Normal School, Chicago.
Committee on Course of Study in Botany and Zoology,
Central Association of Science and Mathematics Teachers.

THE TREATMENT OF LIMITS IN ELEMENTARY GEOMETRY.

By N. J. Lennes,

Wendell Phillips High School, Chicago.

SECTION I. GENERAL PRINCIPLES.

To prevent misunderstandings as to the character of the questions at issue we review in detail some of the principles which are fundamental in synthetic geometry. This will be all the more pardonable, since the situation in elementary geometry is unique among the subjects of secondary instruction. In practically all other subjects there is a direct and, in many cases, a highly developed connection between advanced scholarship and even research on the one hand and elementary instruction on the other. Not so with geometry. It is probably safe to estimate that not more than one in a thousand of the teachers of elementary geometry has studied the subject in a university or college, unless perchance it was solid geometry in the freshman year. Nor is there any reason to suppose that the private studies of any considerable number of these teachers have brought them into contact with the great advances which have been made during the last few decades in synthetic geometry.

Similar statements apply to our text-books. With few exceptions the texts have been written by men of limited mathematical outlook, who are not conversant with the modern aspects of the subject. The books that are exceptions to this rule are written by men not engaged in secondary instruction. Consequently, their books though more scholarly than others, are less teachable.*

School boards and teachers alike unqualified to judge of the comparative merits of the books as regards scholarship, naturally choose teachable books. Thus it comes about that our most scholarly texts have little chance of reaching the hands of the student.

Geometry consists of a set of propositions about points, lines,

* There are, however, exceptions to this rule and the exceptions work both ways. Some books written by university professors are quite teachable, while others written by such men are wretched as regards scholarship.

planes, etc. These words represent concepts concerning whose properties there is a remarkable unanimity among those members of the race whose ideas of space have been formulated into definite propositions. The points of disagreement are quite insignificant compared with those on which there is practically complete agreement.

The prime business of the geometrician is to organize these space ideas into a coherent set of propositions. The program from the time of Euclid to the present day has been:

1. To select a certain body of propositions about the objects points, lines, and planes, which are set down without proof. These propositions are called *axioms.*

2. To derive from these axioms, by means of recognized logical processes, a much larger body of propositions, which are called *theorems.*

It is required of a set of axioms:

(a). No one axiom shall be provable from the others.

(b). It shall be possible by *means of the axioms, without falling back on our intuitions of space,* to prove every theory of geometry which it is desired to prove.

Proofs that a certain proposition cannot be proved by means of a given set of axioms are of comparatively recent origin,—the first being the now famous proof by Lobachevsky that the parallel-line axiom cannot be proved by means of the other axioms of Euclid. Much work along this line has been done in recent years, but the time is yet far off when such work should be introduced into secondary instruction.

In connection with the second requirement on a set of axioms it is granted that geometry is based entirely upon our space intuitions. But these intuitions must be embodied in *definite statements once for all.* If, after setting down our axioms, we find that they are not sufficient to prove certain propositions about space which our institutions affirm to be true, then we must either create a new axiom or agree that our geometry shall not correspond to our intuitions in this respect. We must always be certain that no new assumption (axiom) shall creep in in the course of argumentation under cover of such expressions as "obviously," etc. If, for instance, in a proof it becomes convenient to construct a segment from a vertex of a triangle to the middle point of the opposite side, the question arises whether or not

every segment has a middle point, or indeed whether or not there is a point at all on every segment. The pupil finds no trouble here. Obviously, such point exists. His intuition gives the answer at once. But as teachers, or text-book writers, our question is: *Do* our *axioms* furnish the answer? Do we have an axiom which says that between every two points of a line there is a third point, or can we prove from our axioms that such point exists? If not, then we have no right to speak of a line from the vertex of a triangle to a point on its opposite side. The general question is: Have we included, directly, or indirectly, in our axioms all our intuitions about space? To make sure that we are not letting new assumptions creep in by the way, it is often well (for critical study but *not for elementary instruction*) to denote points, lines, etc., by names which have no intuitional connotations. Chinese names might be used. Then in argumentation all we should know about these queer names and the objects they represent would be contained in the axioms in which these words are used. But, it is said: "These words would have to be defined." The answer brings us to the second part of Section 1, which is concerned with definitions.

DEFINITIONS.

In a logical system such as geometry a *definition may be regarded as an agreement to use a single word, or phrase, instead of a more complicated expression* Thus we agree to use the word "circle" when we wish to speak of that set of points in a plane which are equally distant from a fixed point in the plane.

In geometry we raise no question as to the meaning of the purely logical terms such as "is," "belongs to," "class of objects," etc. The terms whose meaning we call in question are those which may be called geometrical terms such as "point," "line," "segment," "quadrilateral," etc.

The fundamental proposition about definitions is that *not every term* can be defined. It is a logical impossibility to do so. For instance, any definition of the word "point" must contain other words, possibly, "extension" or "position." These words must be defined in terms of still other words and so indefinitely, unless we come back to words already in this chain. Hence, we are met at the very outset by the fact that some essentially geometrical terms must be left undefined.*

*I should say that those terms are best left undefined which represent the simplest concepts—concepts whose properties are most clearly marked out by intuition. Never define a word representing a simple concept in terms of words representing more vague or complicated concepts.

In the light of this principle we examine some of our common text-books. The following is from Van Velzer and Shutts' geometry, * a book with many excellent qualities:

"A point is that which has simply position, but neither length, breadth nor thickness."

"Line is that which has length, but has neither breadth nor thickness."

Or to quote Phillips and Fisher's Geometry.**

"A point has position, but no magnitude."

"If a point moves it generates a line."

These are fairly typical examples. Similar definitions are given of planes and solids.

Writing the definitions of Van Velzer and Shutts in the form of equation we have:

Point=that which has simply *position,* but neither *length, breadth,* nor *thickness.*

Line=that which has *length,* but neither *breadth* nor *thickness.*

The definitions of Phillips and Fisher are:

Point=that which has *position* but no *magnitude.*

Line=that which is *generated* when a point *moves.*

The words "point" and "line" are defined in the first case by means of the words "position," "length," "breadth," and "thickness" and in the second case by means of the words "position," "magnitude," "generated," and "motion."

It is a matter of personal opinion as to whether or not these definitions serve to illuminate the concepts "point" and "line." Personally, I am inclined to think that they do not, but this is mere opinion. When it comes to using these definitions in argumentation the matter is different. If the definition "Point=that which has position but no magnitude" is to be used in proving a proposition involving the word "point," then we must be able to prove the proposition when "that which has position but no magnitude," is substituted for the word "point." Now, "magnitude" and "position" are left undefined, and neither of these terms occurs is an axiom. (In Phillips and Fisher's book from which the definition under consideration is taken).

*"Plane and Solid Geometry, Suggestive Method." C. A. VanVelzer, Professor of Mathematics, University of Wisconsin, and George C. Shutts, Professor of Mathematics, State Normal School, Whitewater, Wisconsin (1894), Tracy, Gibbs & Co., Madison, Wisconsin.

**Elements of Geometry, by Andrew W. Phillips, Ph. D., and Irving Fisher, Ph. D., Professors in Yale University. Harper & Brothers, New York (1897).

But if an undefined term is given and no axioms are given stating its properties* then it is absolutely impossible to *prove*
Foot note page 7
any proposition whatever which contains this term (except such logical properties as are conceived to be necessary conditions of *any* object of thought) consequently this definition cannot possibly be of any logical significance whatever in the book mentioned. Every geometrical word must either be one of the undefined symbols whose properties are given by a set of axioms or it must be defined, directly or indirectly, *in terms of these undefined symbols.* The important point here is that no *undefined symbol whatever can exist in geometry unless it occurs in the axioms.*

SECTION II.

Criticism of the Treatment of Limits in Common Texts.

In this section we test the usual treatment of limits in elementary geometry by the principles laid down in Section I.

The fundamental theorem on limits encountered in every text on elementary geometry that I have seen is this:

"If two variables are equal their limits are equal." This theorem is bad on general principles. In the first place a variable does not in general have only one limit, but a great many. It all depends upon what part, so to speak, of the variable is considered. The variable x^2 has one limit as x approaches zero, another as x approaches unity and so on, indefinitely. Hence it is clear that the statement of the theorem is highly elliptical. A full statement would be very complicated. (It can hardly be presumed that real clearness can ever be gained by omitting essential parts of a statement unless it is assumed that the reader is already acquainted with the omitted parts.) In the second place it is mere nonsense to speak of two equal variables.—If two variables are equal they are *the same variable.* It is the same kind of statement as saying that two equal numbers (which are the same number) have the same properties. The real question is whether or not the one variable has a limit. This, however, is a very complicated question. Fortunately, there is no need in elementary geom-

*The distinction between definitions and axioms is not considered here. On this point see O. Veblen. "A System of Axioms for Geometry," Transactions of the American Mathematical Society, Vol. 5, p. 346 (1904), and E. V. Huntington, "A Complete Set of Postulates for the Theory of Absolute Continuous Magnitudes"; Trans. Am. Math. Society, Vol. 3, p. 364 (1902).

etry for considering this question in the general form in which it is usually stated.

Upon this unfortunate theorem about the equality of the limits of two equal variables is based a more or less elaborate theory of limits which is used in deveoloping the theory of ratio and proportion, the theory of lengths of curves, areas of plane curvilinear figures, volumes and surfaces of curvilinear solids. We proceed to consider in detail the current treatment, by means of limits, of ratio and proportion, and of the lengths of curves.

The word ratio is defined for commensurable segments, angles, arcs, numbers, etc. Then we usually find the following theorem: *"In the same circle or equal circles two angles at the center have the same ratio as their intercepted arcs."* This theorem is proved for two cases. 1. when the angles and arcs are commensurable. 2. when the angles and arcs are incommensurable. No definition is given of the ratio of two incommensurable arcs or of the ratio of two incommensurable angles. Hence these expressions are undefined symbols, and since they do not occur in any of the axioms used in these books it follows that the theorem proposed *cannot be proved.* This is not a case of the student not being bright enough to make the proof. It is a case of teacher and text-book writers not being clear enough in their thinking to see that no mortal (or immortal for that matter) can ever make the proof. Precisely similar remarks apply to the various other theorems in ratio and proportion where the theory of limits is used. Puzzle: Find the error in the alleged proofs.

Essentially the same error occurs in the treatment of the length of curves. An example will illustrate. The following theorem is set down without a previous definition of the expression "length of arc" or "length of circle."

Theorem. "The length of the circumference of a circle is the limit of the perimeter of a set of inscribed regular polygons as the sides of the polygons are made to diminish indefinitely."

But what is the definition of "length of circumference." The writer is willing to offer a modest prize for the promotion of research to the person who succeeds in defining the "length of circle" without giving in substance the above *theorem* as his definition. It is to be understood that the definition shall not contradict the theorem. No new undefined symbol and no new assumptions (axioms) are to be introduced.

We reiterate: Such theorems *cannot be proved* and again we propose the puzzle: Find the error in the alleged proofs. The mistake necessarily involved is concealed in various ways and with various degrees of ingenuity. One book, on whose title-page appears such dignified weight of authority as to intimidate almost any critic,* proves as a lemma the following theorem:

"The circumference of a circle is less than the perimeter of any circumscribed polygon or any enveloping curve." Of course, the proof of this lemma is as impossible as that of the main theorem. But, even if this lemma were granted it would still be impossible to prove the main theorem. We should have to prove besides that the length of the circle is greater than the perimeter of any inscribed convex polygon. Why one should attempt to prove the first of these two and not the second is not easily understood. What has been said about the treatment of the length of the circle applies in minutest detail to the treatment of areas of curvilinear figures, surfaces of curvilinear solids and volumes of solids.

As indicative of the situation both among teachers and authors of text-books I quote the following extracts from a note by Mr. Sanders in *School Science and Mathematics*.** (Mr. Sanders is himself the author of a very teachable text-book on geometry in which is found, however, every error pointed out in this paper.)

"Our early American geometries, which were largely translations from the French, followed the plan of Legendre and *assumed* without proof, that the circle was the limit of the inscribed regular polygons when the number of sides is indefinitely increased. The modern treatment of limits was introduced into our geometries to supply a proof for this assumption. The proofs of these propositions in plane geometry in our American geometries is fairly logical, but what is given as proofs of the analogous propositions in solid geometry are assumptions pure and simple as were those of Legendre." Mr. Sanders then hits the nail by showing that some attempts at proofs of theorems in solid geometry, which we have seen are unprovable, are not after all rigorous proofs and then closes with the following statement: "The fact that ninety per cent. of the geometries

*The text by Phillips and Fisher.

**Alan Sanders, *"Is the Treatment of the Theory of Limits in our Elementary Geometries Logical?"* *School Science and Mathematics*, Vol. V. (1905), p. 396.

used in this country give no proof," (Mr. Sanders means to say that the proofs *attempted* do not as a matter of fact prove anything) "for the propositions quoted relating to cylinders, cones, and spheres is a matter worthy of the serious consideration of the teachers of geometry." *Shades of Euclid!!* All the teachers of geometry in this country combined can no more prove these theorems than they can raise a two-year-old calf in a day.

(*To be continued.*)

EXPERIMENTAL STUDIES IN YELLOW FEVER AND MALARIA AT VERA CRUZ.

The U. S. Public Health and Marine Hospital Service has published a bulletin on the experimental work done by assistant surgeons M. J. Rosenau, Herman B. Parker, Edward Francis and George E. Beyer, the conclusions of which are as follows: The cause of yellow fever is not known. The *myxococcidium segomyioe* is not an animal parasite. Yeast cells sometimes stimulate the coccidia in form and staining reaction.

The infection of yellow fever is in the blood serum early in the disease. No abnormal elements that bear a casual relation to the disease can be detected in the serum or in the corpuscles with the best lenses at our command.

The infective principle of yellow fever may pass the pores of a Pasteur-Chamberland B filter. Particles of carbon visible with Zeiss lenses pass through both the Berkefeld and Pasteur-Chamberland B filters. Because the virus of an infectious disease passes a Berkefeld or Pasteur-Chamberland B filter it does not necessarily follow that the parasite which passed the filter is "ultramicroscopic", or that it may not have elsewhere another phase in its life cycle of large size. The filtration of viruses may succeed or fail, depending upon the character of the filter, the diluting fluid, the pressure, time, temperature, motility of the particles and other factors.

The period of incubation of yellow fever caused by the bites of infected mosquitoes is usually three days, sometimes five days, and in one authentic instance six days and two hours; but when the disease is transmitted by such artificial means as the inocu-

lation of blood or blood serum the period of incubation shows less regularity.

Yellow fever may be conveyed to a non-immune by the bite of an infected *Stegomyia fasciata;* but the bites of *Stegomyia* which have previously (over twelve days) bitten cases of yellow fever do not always convey the disease.

Fomites play no part in the transmission of the disease.

The tertian and estive-autumnal malarial parasites will not pass the pores of a Berkefeld filter.

There is a poison in the blood during the chill of tertian infection which, when injected into another man, caused chill, fever and sweating. This poison, while present in a case of tertian during the rise of temperature, could not be demonstrated in the blood of a case of estivo-autumnal fever during the decline of the paroxysm. While this poison reproduced the symptoms of the disease, still the data are too limited to consider it the malarial toxin.

Stegomyia fasciata is a domestic insect. It is most active during the day, but will bite at night under artificial light. The female lay eggs at intervals; the maximum number of eggs laid by one insect observed was 101. The mosquito does not always die directly after ovipositing.

Stegomyia fasciata may bite and draw blood from cadavers, although the danger from spreading the infection from this source is remote.

Male and female *Stegomyia fasciata* may pass a screen containing 16 strands, or 15 meshes to the inch, but not one of 20 strands, or 19 meshes to the inch.

Tobacco smoke produced by burning two pounds per 1,000 cubic feet with an exposure of two hours is sufficient to kill *Stegomyia fasciata.* This method is objectionable on account of the yellow stains and disagreeable odor. Pyrethrum burned in the proportion of one pound per 1,000 cubic feet with an exposure of two hours will stupefy *Stegomyia fasciata;* it requires two pounds to kill them outright.

From the limited number of experiments made and from previous experiments it is thought that sulphur dioxid is the best of the gaseous insecticides for this purpose. Formaldehyde gas is not an insecticide, and therefore not applicable.—*Science.*

CULTURE COURSE, (II).

By T. M. Blakslee,
Central City, Iowa.

[CONTINUED FROM THE NOVEMBER NUMBER.]

(B.) THE ROOTS OF UNITY.

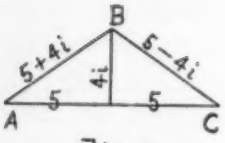


Fig. 1.

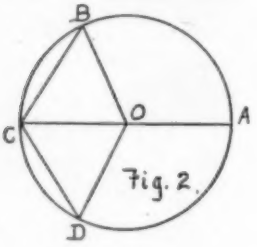


Fig. 2.

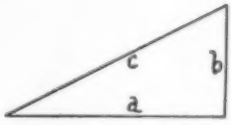


Fig. 3.

As $-1=1_{2r}=(1_r)^2$

$\sqrt{-}=1_r=1_1 \quad r=90^0$

1_r or 1_1 if right angle be the unit of angle, is called the *tranverse* unit and is denoted by *i*. 1_0 is the *initial* or fundamental unit.

Any vector can be expressed as a complex in the form of the sum of an *initial* and a *transverse*. Thus, c=a+bi.

Ex. 1. Solve x+y=10, xy=41. (Fig. 1.)

Ex. 2. Show that each of the complex cube roots of unity is the square of the other.

Their sum is —1, and the sum of all three cube roots is 0. (Fig. 2).

Ex. 3. Show geometrically, that the three cubes roots of unity are $1, -\frac{1}{2}+\frac{1}{2}\sqrt{-3}$ and $-\frac{1}{2}-\frac{1}{2}\sqrt{-3}$

SECTION III. TANGENTS TO PLANE CURVES.

As it is desired to make this Section clear independently of the last, we may seem to simplify unduly.

If one is going north-east along a ray, it is easily seen that he is going north and east at equal rates.

If he is going along a ray midway between N. and N. E., the parts of his motion in these two directions are equal.

If he go N., he is not going E. at all.

If he go E., he is not going N. at all.

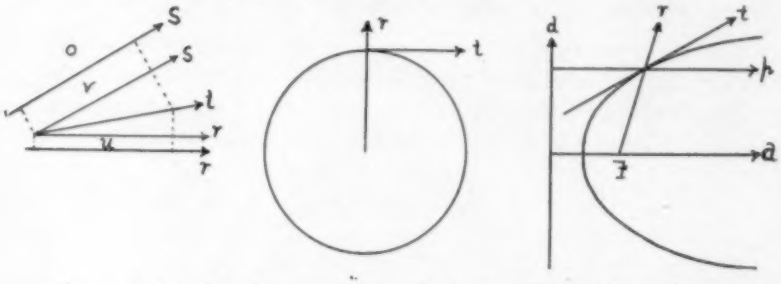
Along any other ray he is going both N. and E.

That is, a slide along a ray has a part along any other ray not transverse to it. The parts of any motion along parallels are *equal*. Motion along a ray is said to be *rectilinear*.

Theorem. If a rectilinear slide have its parts parallel to two rays equal, the line of motion bisects the angle between the rays. (*rt. triangles with hyp. and sd. equal.*)

DEFINITIONS.

The tangent to a plane curve at any point is the ray of motion of the generating point (*generatrix*) at that point.

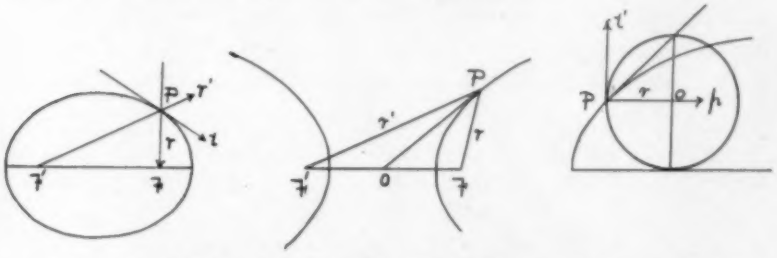


(1). A Circle, (circumference), is the path of a point moving so that its distance from a fixed point is constant. (The radius is constant).

(1a). The tangent to a circle at any point is perpendicular to the radius to the contact-point. Otherwise, there would be part of the motion along the radius.

(2.) A Parabola is the path of a point moving so that its distance from a fixed point, (*the focus*), always equals its distance from a fixed ray, (*the directrix.*)

(2a). The tangent to a parabola at any point bisects the angle between the focal radius (produced), and the perpendicular to the directrix through the contact-point.



(3). An Ellipse is the path of a point moving so that the *sum* of its distances from two fixed points, (*foci*), is constant.

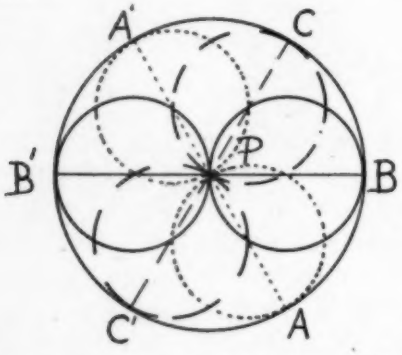
(3a). The tangent to an ellipse bisects the angle between one focal radius to the contact-point and the other produced. One radius must increase as fast as the other decreases.

(4.) An Hyperbola is the path of a point moving so that the *difference* of its distances from two fixed points is constant.

(4a). The tangent to an hyperbola bisects the angle between the focal radii to the contact-point. They increase or decrease at the same rate.

(5.) A Cycloid is the path of a point in the circumference of a circle rolling on a ray.

(5a). The tangent to a cycloid bisects the angle between the parallel to the base and the tangent to the generating circle through the contact-point. The velocities of translation and of rotation are equal.

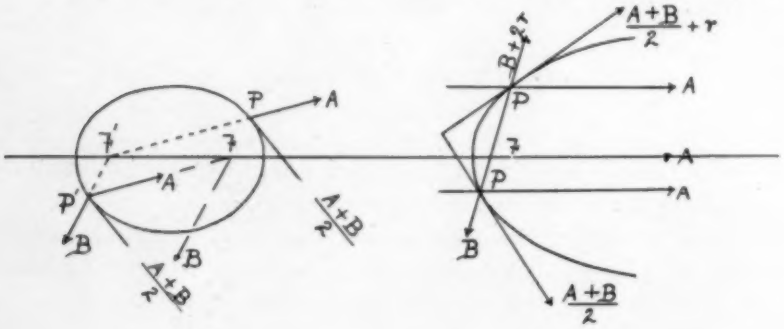


Cor. I. The tangent to a cycloid passes through the upper vortex of the corresponding position of the generating circle.

Cor. II. If a circle roll within another circle of double its diameter, every point in the circumference of the smaller circle describes a diameter of the larger.

For the instant, it rolls on the tangent to the larger circle. Apply Cor. I.

Note. Here we have a succession of rotations giving a recti-



linear motion. Compare Maxwell's theory that the light motion is the result of magnetic rotations.

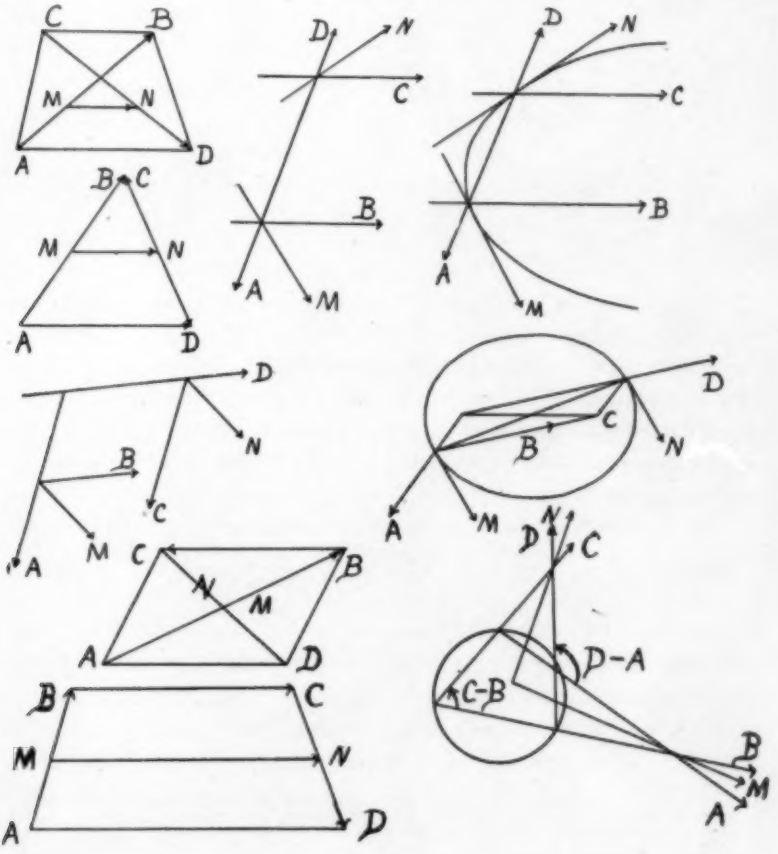
Ex. 1. Tangents at the ends of a diameter to an ellipse are parallel. (Center bisects diameter).

2. Tangents at the end of a focal chord of a parabola are at right angles.

The following theorem not merely includes the special cases for which figures are given but others.

Theorem. The difference of the averages equals the average of the differences. The averages are those of the 1st and 2nd, 3rd and 4th. The differences are those of the 1st and 4th, 2nd and 3rd.

Proof. Each result is 1/2(C+D—A—B), where A, B, C, D are the quantities, M is the average of A and B, N of C and D.



SOME DIRECTIONS FOR ELEMENTARY LABORATORY WORK IN PHYSIOLOGY AND HYGIENE.

By Louis Murbach.

[CONTINUED FROM THE NOVEMBER NUMBER.]

RESPIRATION*

Composition of Air—Nature of Components.

Note.—By experiments we can learn many things about breathing. Beginning with the composition of air, we learn that it is a mixture of gases, those best known being oxygen, carbon dioxide, and nitrogen.

Experiment 1. To learn approximately the amount of each, a tube containing.....millimeters (or may be measured in cubic centimeters) of air closed at one end, is inverted in a solution that absorbs oxygen.

Note.—The tube should be in a flat dish and the mouth of the tube dip a little below the surface.

In one-half hour the contents of the tube are again measured in mm. or in cc. The result is, of course, the amount of gas and the amount of fluid in the tube. According to the conditions of the experiment, what must be the gas left in the tube? What has caused the fluid to rise? In other words what was in the amount of space now occupied by the fluid? Figure out the proportion and tell in per cent.—(a) the kind of gas left; (b) the kind of gases replaced by the fluid.

Note.—The amount of carbon dioxide in the air is so small that it may be ignored. Any alkali will absorb it. The fluid for absorbing oxygen is a solution of pyrogallic acid in strong alkali.

Experiment 2. To learn the nature of oxygen: A lighted stick of charcoal is placed in the bottom of a test tube and some oxygen carefully admitted by placing the delivery tube from the oxygen reservoir into the test tube. How does the oxygen affect the spark?

Note.—A spark or glowing charcoal is used in getting an idea of the effect of the gases on living substance, since there is thought to be a close similarity between living substances and burning things. However, the amount of oxygen used by the tissues is regulated, not by the amount offered, but by the demand of the tissues.

What effect will oxygen have on the tissues if the similarity just referred to is correct?

Experiment 3. To learn the nature of nitrogen: A card or stiff paper is slipped under the mouth of the test tube in the

*Note.—The part on Respiration and first experiment on ventilation are printed again on account of the unexplained omission, from the November number, of that portion in Respiration between the second note on this page and experiment 5 a.

solution, experiment 1, so as to turn over the tube without losing much of the gas. Then the lighted end of the stick of charcoal is introduced into the tube to see if the nitrogen has any effect on the spark. What is the result? What does the result of experiment 3 indicate as to the two actions that nitrogen may have on the tissues?

EXPERIMENT 4. To learn the nature of carbon dioxide: (a) Behavior with the spark. A test tube full is drawn from the carbon dioxide generator on the supply table. A burning splinter or stick of charcoal is inserted into the carbon dioxide. What is the effect on burning? What effect will carbon dioxide probably have on tissues (Cf. Note Experiment 2). (b) Its weight compared with air. A burning candle is set in the bottom of a narrow jar and immediately some carbon dioxide is poured into the jar. Watch the candle carefully to see what occurs. Give reasons for your conclusions as to the relative weight of carbon dioxide and air. In what part of a room would carbon dioxide naturally accumulate and do harm?

PRODUCTS IN EXPIRED AIR.

EXPERIMENT 5a. Preliminary. To learn the behavior of carbon dioxide with limewater: A centimeter's depth of clear lime water is placed in a test tube and some known carbon dioxide is received into the test tube from the delivery tube of a carbon dioxide generator. The test tube is then closed with the thumb or the hand and shaken. If no result yet appears, add some more carbon dioxide and shake again. How would you describe the appearance of the mixture? If now you are told that only carbon dioxide behaves this way (give this result) with lime water, can you tell what use you can make of this experiment; what you learn to do? If not certain of the answer leave until after the next experiment.

EXPERIMENT 5b. To learn if there is any carbon dioxide in expired air (compare note, experiment 1, above): One centimeter's depth clear lime water is poured into test tube and the test tube held under one nostril in such a way that the breath is forced into the tube. This is done several times, each time removing the test tube when a fresh breath is taken so that no air will be drawn out of the tube. The tube is then closed and shaken as in experiment 5a. What is the resulting appearance of the lime water that was previously clear? What is present in

expired air? Where did you learn to test for it? Can you now tell what you learned in experiment 5a.

EXPERIMENT 6*. To learn whether there is relatively more or less carbon dioxide in the breath than in the air: the air in a tube with one cm. deep lime water is shaken, more air is allowed to enter, the tube shaken again as above, experiment 5b. The amount of turbidity or milkiness (precipitate) in the lime water of the tube with only air, compared with that of the breath as seen in experiment 5b will enable the student to draw a conclusion.

EXPERIMENT 7*. To learn whether there is any oxygen in the air normally expired: a bent glass tube from the mouth is inserted under a graduated tube (an ordinary small graduate will do) filled with water and inverted in a dish of water. A measured portion of water (simply reading the graduated tube) is replaced by air blown from the lungs through the glass tube. The water in the dish is now made strongly alkaline by adding caustic potash. After half an hour (when the fluid rises no longer, showing that all the carbon dioxide has been absorbed, (Cf. note Ex. 1) the amount of gases left in the tube is again noted. What gases would be left? Now pyrogallic acid is added to the alkaline solution and left until the fluid rises no longer. What indicates whether there is any oxygen in expired air? What is the gas left? Read the amount? From the various readings of gas the proportion of carbon dioxide, of oxygen, and of nitrogen in expired air may be told.

EXPERIMENT 8. To find other products in respired air a clean dry test tube is held so that the breath enters it. The tube is then held to the light so as to see anything that may collect on its sides. Be careful to distinguish what you see from what you learn in this experiment and write it out accordingly.

EXPERIMENT 9. To learn whether there is any difference in the temperature of inspired and expired air. The temperature of the air in the room is read.

NOTE.—While near the thermometer and making the first record, the student must avoid breathing on it or letting the warmth of his body come near enough to make a false record.

After carefully noting the temperature of the air breathed in, the expired air is gently directed on the bulb of the thermometer for some time just as in warming the hands. The

temperature is immediately noted. Is the temperature now indicated higher or lower? What does this tell about the air breathed out?

EXPERIMENT 9*. To learn of another product in expired air. At home a clean fruit jar or bottle is filled with breathed air as full as possible by breathing gently into it for a long time. It is then closed air tight and set in a warm place for a day. The next day the *odor* is examined and the experiment written up in school. What kind of matter can undergo decay in a warm place and give such an odor? What is thus learned to be in the breath?

As a summary, tell four changes air undergoes from inspiration to expiration.

SOME SOURCES OF CARBON DIOXIDE.

In order to be on the lookout for danger from carbon dioxide it is well to know some of its sources.

EXPERIMENT 1. A funnel is placed over a gas burner so as to catch as much of the products of burning as possible. A tube conducts the products into a test tube containing 1 centimeter's depth clear lime water. This is thoroughly mixed by shaking. What does the result indicate? (Cf. ex. 5a.)

EXPERIMENT 2. A dish of clear lime water is placed under a bell jar with some decaying organic matter and left until the next lesson. When again seen what is the result? Conclusion?

NOTE.—It may be necessary to stir the dish of lime water to make the result more evident.

From these two experiments and five (5b) the student is to enumerate the sources of carbon dioxide with which we are concerned.

VENTILATION.

NOTE.—At this point it may be well to learn the principle underlying ventilation to see how the carbon dioxide may be removed.

EXPERIMENT 1a. A lighted candle is lowered into a tall narrow glass jar. How does it behave after some time? Can you explain the result? (b) The lighted candle is again lowered and a tin partition is lowered in the jar so as to make two flues. How does this affect the burning candle compared with (a)? If you cannot now explain you will understand better if you will hold a smoking paper or stick over each flue (each side of the partition). What behavior of air underlies all systems of ventilation?

BACTERIA (Germs and Disease).

INTRODUCTORY NOTE.—It is the object of the following experiments to find the sources of germs (bacteria) that cause disease, destroy goods, and benefit man in some ways; to learn their life-history, how they are propagated, and how to destroy them. A few days before this lesson some hay tea, broth, or cooking gelatine has been set aside as food ordinarily might be kept. This forms a culture medium for germs. From the sample culture learn to identify colonies of bacteria (spots of colored slime), and moulds.

EXPERIMENT 1. Seven slices of potato 1 cm. square by 3 cm. long are placed in separate test tubes, water enough poured over them to cover, and the tubes then plugged loosely with wads of cotton batting.

NOTE.—It is better if the cotton has been previously baked in an oven for some time.

The water in the test tubes is boiled for a few minutes three days in succession. Only steam should pass through the cotton; if water wets the cotton a new plug must be introduced and the specimen again boiled. Students may do these in groups according to the number in the class, but each one must inform himself of everything done and write fully the essential conditions for each experiment (specimen). After the boiling has been completed on the third day the tubes are labeled a), b), c), d), e), f), g), the water poured off, and the experiment continued as follows: a) To find whether the moisture is necessary for the growth of bacteria the potato in a) is "inoculated" by transferring some bacteria on a wire from the sample culture, above, to the slice of potato; the latter is then dried slowly, returned to the dried test tube and again closed with the cotton. To learn some sources of bacteria: b) to find whether there are any in the air the potato in the test tube b) is exposed to the air for about twenty-four hours and is again stopped with cotton: c) to find if there are any bacteria in tap-water a little drinking water is poured over the slice of potato in c) and poured off again, the cotton plug being returned as soon as possible; d) to learn whether there are any bacteria in dust; some dust is swept up on ledges of the wall or tops of cases and sprinkled on the potato in tube d); this is also to illustrate infection from dirt getting into wounds; e) to learn whether one can destroy bacteria in such cases (wounds, etc.) dust is sprinkled on the potato in e) from the same lot that was used in d) and corrosive sublimate solu-

tion, 1/1000 strong, is poured over the dusted slice of potato and left until the next exercise. The corrosive sublimate may now be poured off and the cotton plug returned and the tube set aside for results. To learn whether "fumigation" of rooms as it is practiced after contagious diseases, is effective in killing germs, f) is treated with some of the same lot of dust used in d) and the test tube is then set into a chamber (fruit jar) containing one ounce of Formaline and the latter sealed air tight. Finally, to learn what the effect is of boiling the potato slice three times in succession at intervals of not less than nine or more than twenty-four hours g) is set away with nothing but the moist boiled potato in the tube kept carefully plugged with the cotton. In two or three days the results should begin to show.

NOTE.—Students may write up the purpose, conditions, results and conclusions for each experiment separately, or, after following out the above very carefully in stating purposes and conditions, may write the results together in proper order, then draw conclusions in the same order, using in each case the proper letters to designate certain specimens. The former method would be simpler, and the better, as the results are not all ready at the same time. In looking for results the student must bear in mind that the presence of moulds in a culture does not prove, or may not even indicate, that there are bacteria present; he is to recognize the latter by the appearance of tiny or larger spots of slime. In the introductory study the student should see bacteria from a slime colony under the microscope. The following questions and suggestions may help the student in working out his conclusions.

State whether or not colonies of bacteria developed in a); the probable reason. How does b) prove this? What does the result in b), and that in c) show as to the common origin of bacteria in each case? If the student is not clear in this and subsequent tests compare them with the result in g). How does g) prove that the bacteria in c) (assuming that to have been successful), did not come from the air, through the cotton plug? Judging from d) what is the danger in dust? Compare number of colonies with b). How will wounds behave that are made with dirty splinters or instruments? This helps to understand what is meant by "infection." What does e) show in regard to the treatment of wounds? What experiment shows that bacteria would have developed in e) if the corrosive sublimate had not been put on? Wounds should always be treated with corrosive sublimate (1/1000) or some other antiseptic solution. This illustrates "asepsis." Would you expect bacteria to have developed in f)?

Why? What is shown by the experiment f)? It is an illustration of "fumigation." Why did the bacteria in tap water used on potato, in g) not develop? This is an illustration of "sterilization" by boiling.

From the experiments the student may be able to tell one or two of the conditions of growth of bacteria, how they may be guarded against by knowing their sources, and how they may be destroyed.

NOTE.—Bacteria are microscopic degenerate plants. They are both harmful and useful to man and therefore of economic importance. According to their form they are divided into three groups: 1. Micrococci (like lock-jaw germs), 2. Bacilli (like consumption germ), 3. Spirilla (like cholera germs).

NOTE.—In all foods we find one or more substances that always give the same reactions. There are only four of these substances no matter how many foods. They are proteid (also called albumen), fat, sugar and starch. Everyone is familiar with all of these except, perhaps, proteid, and this will be more familiar when we learn that the white of egg and lean meat are common and quite pure proteids. Sugar and starch are chemically so similar that they are classed together. They are called *carbohydrates*. Proteids, fats and carbohydrates are also called "nutrients" and food-stuffs. To learn what nutrients are present in the common foods we must learn to tell each nutrient by a test which nothing else except that nutrient will give.

EXPERIMENT 1a). To learn the behavior of starch toward iodine: A small piece of known starch is placed in a white dish and a drop of reddish yellow iodine solution is added to the starch. What is the resulting color? Break the piece of starch to see the paler shades where less iodine penetrated. All starches give this color reaction. If you cannot tell the conclusion to this part of the experiment leave it, as heretofore, until you have done the other part. Then return and write it out. 1 b) To learn in which of the substances commonly used for food there is starch, test in the same way as in a) the cut surfaces or crushed wheat and corn kernels, a bit of scraped potato, banana, apple, onion and other things. The b) part of the experiments may be reported in a table similar to the one recommended under "Acids and Alkalies." Use the words *much, little, no* starch in the column for conclusions. This part of each experiment need not be farther written up, but the a)-part should be written out.

EXPERIMENT 2a.) To learn how to tell where there is proteid: A few drops of nitric acid are poured on a little known

proteid in a test tube and the mixture heated gently to boiling—no more. This is then cooled by setting the test tube in water.

NOTE.—Strong acids and alkalies mixed while hot unite with explosive violence.

When cool to the touch ammonia is added until the mixture is alkaline. Apply in the way you have learned to test for alkalies. As soon as the solution is alkaline a bright color appears—what is it? If no other substances except proteid give this color under these circumstances what have you learned in this experiment?

Apply what you have learned (b)—to find if there is any proteid in the following: crushed peas, every other student; crushed beans, all the rest of the class;* butter, cheese, onion, *beef tea. Record results and conclusions in the table as before for the b)-part of the experiment.

EXPERIMENT 3. To find in what food there is sugar: a) Preliminary. A few granules of grape sugar (glucose) in a test tube are covered with a cc. (a medicine dropper full) of strong caustic potash solution, then a few drops of saturated solution of copper sulphate are added, and the whole is mixed by shaking. The mixture is then brought to boil over a Bunsen flame, watching carefully for any change of color. Just as soon as the mixture begins to turn yellow boiling should cease, otherwise the correct color test, orange, will be passed over. Almost a brick-red is also obtained.

NOTE.—The student should remember that these colors are obtained with pure, known grape sugar, and that in mixtures with other substances he cannot expect to get such clear results; but yellowish or brown colors will lead him to suspect sugar, and he may make sure by boiling some of the substance to be tested in water, then testing a little of the water solution. All kinds of grape sugar and some others give the above result.

What have ,you learned in this experiment? b) Potato banana, sour apple or lemon, and any of the grains used for food may now be tested for grape sugar, then the results and conclusions tabulated as before.

*c) Some cane sugar (granulated) is tested in the same way as was the grape sugar. What result? To some fresh cane sugar in a test tube a few drops of hydrochloric or any acid are added, the mixture boiled and when cool it is treated the same as grape sugar. What result do you now get? Try to explain as

conclusion, what has taken place. For a practical application of this, sweet corn and sugar beet may be tested for grape sugar; then proceed acording to the result obtained, and explain.

EXPERIMENT 4. To determine in what foods there is fat. a) Preliminary. A few drops of chloroform are poured into a clean dish or better still on a piece of writing paper. In a few minutes examine to see if anything is left. How do you explain? Over a tiny bit of fat (size of a pin head in the same dish) some chloroform is poured. By moving the dish properly the chloroform will repeatedly wash the fat. The remaining liquid is now transferred to a piece of writing paper and held in the air until the odor of chloroform is gone. Hold the paper toward the light to see what is left on it. What would you call it if it were on a garment. *What was the use of first putting chloroform alone on dish or paper? b) To apply this experiment (or rather what you learn: b) Crushed wheat or buckwheat, flax-seed meal, potato, etc., are tested, and the results and conclusions recorded in the table already prepared.

MILK.

Milk is said to be a good all around food, especially for children. Its quality or richness may be estimated by means of a lactometer. The lactometer is placed in water to see at what degree it stands. (If the lactometer is properly constructed it will stand at zero on the scale.) Now the lactometer is placed in the milk in a tall narrow vessel and the mark (degree) on the scale at the level of the milk read and recorded. Then some of the milk is diluted one-half and again measured with the lactometer. What does the lactometer read in each case?

NOTE.—Milk is passable at 1.035 or even 1.029. What does your result indicate as to the quality of the milk? How could you detect adulterated milk, judging by the experiment of diluting it one-half? Save the milk diluted one-half to measure the proportion of cream the next day, and record the result and conclusion at that time.

(To be Continued.)

Department of Metrology. Notes.

In Pharmacy and Medicine. Dr. H. M. Whelpley, of St. Louis, Secretary of the American Pharmaceutical Association, writes: "The compulsory use of the metric system in city institutions and in government hospitals has assisted wonderfully in making the medical profession realize that medical students are becoming familiar with metric weights and measures. From all I can observe the number of prescriptions written in the metric system has not materially increased since 1900. The greatest advance has been among pharmacists who now quite generally have metric weights and measures for use in filling metric prescriptions. A few years ago they depended upon translating metric prescriptions and using the customary weights and measures. The only pharmacists and physicians who protest against the metric system are some of those who are not familiar with the subject." R. P. W.

A Metric Bill for Australia. The London Daily Mail for April 20, 1905, contains the following from Sydney: "In the forthcoming session of the Federal Parliament the Government will introduce a bill for the establishment of the metric system of weights and measures in Australia. The bill provides that the metric system shall be legalized immediately, while the Governor-General will be empowered to make it compulsory at any time.

The bill would include the establishment of decimal coinage as well, were it not for the difficulty which would be experienced in getting rid of the established currency. The Imperial Government is willing to take £100,000 worth annually, but the Federal Treasurer declares that it would be necessary to export double that amount." R. P. W.

PRODUCING HIGH VACUA.

The German scientific journal Prometheus states that the English physicist Dewar has found a new process for obtaining high vacua, which forms another practical employment of liquid air. It is known already that charcoal possesses the property in a high degree of absorbing gases. Dewar has demonstrated that this absorptive property of charcoal increases manifold if it is cooled to the temperature of liquid air (about 185). The absorption takes place so energetically that if the charcoal is contained in a closed vessel the latter soon becomes void of air.

Where formerly the quicksilver pump had to be worked incessantly for hours and days, it now suffices to attach a tube to the vessel intended to be freed of air, into which some charcoal, preferably of cocoanut shell, is placed, which has been immersed in liquid air. In this manner a vacuum is obtained within a few minutes suitable for producing cathode or X-rays. This method possesses also the advantage that the moisture, which can sometimes be only removed with difficulty from the vessel, is at once condensed in the tube.—*Scientific American.*

Problem Department.

PROFESSOR IRA M. DELONG,

University of Colorado, Boulder, Colo.

Readers of the magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Solutions and problems will be duly credited to the author. Address all communications to Ira M. DeLong, Boulder, Colo.

SOLUTIONS OF PROBLEMS.

ALGEBRA.

1. *Proposed by the Editor.*

Find x, y, z, given by $xy=3(x+y)$, $xz=8(x+z)$, $7yz=9(y+z)$.

Solution by E. L. Brown, M. A., Denver, Colo.

Designating the given equations by (1), (2), (3), we have:

From (1), $x=\frac{3y}{y-3}$ .....(4).

From (2), $x=\frac{8z}{z-8}$ .....(5).

From (4) and (5), $5yz=24z-24y$.....(6).

From (3) and (6), $123z=213y$.....(7).

From (3) and (7), $y=\frac{144}{71}$ .....(8).

From (1) and (8), $x=-\frac{144}{23}$ .....(9).

From (2) and (9), $z=\frac{144}{41}$

By inspection, $x=0$, $y=0$, $z=0$, is also a solution.

Also solved by Minnie Farwell; Byron Cosby; H. H. Seidell; I. L. Winckler; T. M. Blakslee; F. C. Donecker, W. F. Sloan.

2. *Proposed by the Editor.*

A man and a boy agree to dig a patch of potatoes for ten dollars. The man can dig as fast as the boy can pull tops, and he can pull tops twice as fast as the boy can dig. How should the money be divided?

Solution by T. M. Blakslee, Ph. D., Ames, Iowa.

If the ratio of the man's advantage be the same for both kinds of work, suppose it to be r. Then if the boy pulls k hills, the man pulls rk hills. The man digs k hills and the boy $\frac{1}{2}rk$ hills. But the man digs r times as many as the boy.

$k=r\frac{rk}{2}$, $r=\sqrt{2}$. Hence, divide \$10 in the ratio 1: $\sqrt{2}$

This gives \$4.14 for boy and \$5.86 for man.

Correctly solved by H. H. Seidell; F. C. Donecker. Two incorrect solutions were received.

3. *Proposed by the Editor.*

A garrison of 500 men was victualled for 48 days; after 15 days it was reinforced, and then the provisions were exhausted in 11 days; required the number of the men in the reinforcement.

Solution by Byron Cosby, Mound City, Mo.

Let x=number of men in the reinforcement.

500 men for 48 days=24,000 men for one day or ration.

500 men for 11 days=5,500+11x men for one day or ration.

The two are equal as the rations were consumed.

$500\times48=500\times15+(500+x)11.$

$24000=7500+5500+11x.$

$11x=11000$ or $24060-7500-5500.$

$x=1000.$

Also solved by H. H. Seidell, E. L. Brown, I. L. Winckler, T. M. Blakslee, F. C. Donecker, W. F. Sloan.

GEOMETRY.

1. Solutions of this problem are withheld until January on account of the misprint in the October number.

2. *Proposed by the Editor.*

DF is a straight line touching a circle and terminated by the parallel tangents AD and BF. Show that the angle subtended by DF at the centre is a right angle.

Solution by T. M. Blakslee, Ph. D., Ames, Iowa.

I. Let DF touch the circle at T and let O be the center.

The triangles OFB and OFT, ODA and ODT are equal in all their parts. Hence DOF is ½ of a straight angle, AB being a diameter.

II. Angles BFT and TDA being supplementary, the sum of their halves is a right angle. Hence the third angle of triangle DFO is a right angle.

III. This is a special case of the following theorem which is proved in the same manner as I.

DF is a straight line touching a circle and terminated by two tangents AD and BF. Show that the angle subtended by DF at the center is one-half that formed by the radii to A and B.

Also solved by R. F. Emery, I. L. Winckler, H. H. Seidell, Byron Cosby, F. C. Donecker, W. F. Sloan.

3. *Proposed by the Editor.*

In a given triangle inscribe another triangle whose sides shall pass through given points.

No solutions have been received.

TRIGONOMETRY.

1. *Proposed by the Editor.*

If $A+B+C=90^0$, prove that tan A tan B+tan A tan C+tan B tan C=1.

1. *Solution by I. L. Winckler, Cleveland, Ohio.*

$$\text{Tan}(A+B+C)=\frac{\tan(A+B)+\tan C}{1-\tan(A+B)\tan C}$$

$$=\frac{\dfrac{\tan A+\tan B}{1-\tan A\tan B}+\tan C}{1-\dfrac{\tan A+\tan B}{1-\tan A\tan B}\tan C}$$

$$=\frac{\tan A+\tan B+\tan C-\tan A\tan B\tan C}{1-\tan A\tan B-\tan A\tan C-\tan B\tan C}$$

$\tan(A+B+C)=\tan 90^0=\infty$

$\therefore 1-\tan A\tan B-\tan A\tan C-\tan B\tan C=0$

$\therefore \tan A\tan B+\tan A\tan C+\tan B\tan C=1$

II. *Solution by P. E. Graber, Akron, Ohio.*

If $A+B+C=90^0$, then $\tan(A+B)=\frac{1}{\tan C}$. But $\tan(A+B)=\frac{\tan A+\tan B}{1-\tan A\tan B}$. Hence, equating these two values of tan (A+B), clearing of fractions and transposing, the required result is obtained.

Also solved by H. H. Seidell, T. M. Blakslee, F. C. Donecker, E. L. Brown.

2. *Proposed by the Editor.*

Prove that the triangle ABC is isoceles in $2\sin B=\frac{\sin A}{\sin C}$

1. *Solution by E. L. Brown, Denver, Colo.*

Since $\frac{\sin A}{\sin C}=\frac{a}{b}$, and $\cos B=\frac{a^2+c^2-b^2}{2ac}$, we have

$$\frac{a^2+c^2-b^2}{ac}=\frac{a}{c}=\frac{a^2}{ac}$$

and therefore $c^2=b^2$, and $c=b$.

II. *Solution by F. C. Donecker, Chicago, Ill.*

Substituting $\sin A=\sin(C+B)$ in the given relation, and clearing of fractions, we have

$2\sin C\sin B=\sin C\sin B+\sin C\sin B$,

$\sin C\sin B=\sin C\sin B$, giving

$\tan C=\tan B$, and therefore $B=C$.

Also solved by T. M. Blakslee, I. L. Winckler, P. E. Graber.

PROBLEMS FOR SOLUTION.

SUGGESTIONS TO PROBLEM CONTRIBUTORS.

1. Write legibly, being specially particular as to proper names.

2. Write on one side of the paper only, reserving at the top and the left a two-inch margin for the use of the Editor.

3. It is very desirable that each problem be given a separate sheet; also, a separate sheet for any communication not intended for publication.

4. In any algebraic solution or system of equations, only those should be numbered to which subsequent references are made.

5. The simpler geometrical solutions should be so worded that they may be readily understood without the aid of a diagram. If a diagram can not well be omitted, it should be furnished to the Editor in duplicate, one copy on the sheet with the solution, and another copy on a separate sheet done accurately in ink so that it may be photographed.

6. All contributions should be in the following standard form:—

(a). The subject heading (Algebra, Geometry, Trigonometry).

(b). The serial number of the problem in Arabic figures.

(c). The name, academic degree, and postoffice address of the contributor.

(d). The body of the solution.

ALGEBRA.

Proposed by Mary Clemmer Tracy, Passaic, N. J.

Solve a) $1-\sqrt{x}+y=0$, $4-x=y-\sqrt{y}$

b) $x^2+y^2=13$, $x^3+y^3=35$

Proposed by the Editor.

In walking along a street on which electric cars are running at equal intervals from both ends, I observe that I am overtaken by a car every 12 minutes, and that I meet one every 4 minutes. What are the relative rates of myself and the cars, and at what intervals of time do the cars start?

Proposed by the Editor.

Find the sum of n terms of the series

$1+2x+3x^2+4x^3+\ldots\ldots$

GEOMETRY.

Proposed by E. L. Brown, M. A., Denver, Colo.

In a given circle inscribe a triangle whose sides shall pass through given points.

Proposed by the Editor.

To construct a triangle if the radii of the circles, which touch the three sides externally, be given.

TRIGONOMETRY.

Proposed by P. E. Graber, Akron, Ohio.

In a sperical triangle, if $A<90^0$ and $C=90^0$, prove that $(b-c)<90^0$.

MISCELLANEOUS.

Proposed by F. C. Donecker, Chicago, Ill.

A ball 12 inches in diameter is rolled around a circular room 12 feet in diameter in such a way that it always touches both wall and floor. How many revolutions does the ball make in rolling once around the room?

Department of Zoology:

NOTES.

The departmental editor in zoology accepted the responsibilities indicated by his title, sometime last summer. Thus far he has not received anything to edit or review and has had no time in which to prepare material of his own. He now appeals to all who are interested in seeing the Journal become as helpful to teachers of zoology as it is to those in other fields, to come to his assistance by the contribution of articles of a more formal nature, or of notes on laboratory or field methods or on useful literature. He will be glad to receive any suggestions as to any special topics or field of zoology on which anyone would like to have articles prepared. If anyone has a question of which the answer would be likely to be of general interest send it along.

Professor C. F. Hodge of Clark University has recently contributed two articles on biological instruction, which are of interest to teachers in that field. Dynamic Biology and its Relations to High School Courses, is the title of one article and Dynamic Biology in the College, of the other. They appeared in the Pedagogical Seminary, September 1904 and June, 1905.

Professor Hodge also has an article in The Country Calendar for November, which describes the drumming of the ruffed grouse and which is accompanied by reproductions from a remarkable series of photographs of a bird "caught in the act." This bird was one which had been reared from the egg and was so tame that it would drum readily and repeatedly without regard to the proximity of the photographer. From the concluding paragraphs of the article we quote the following statement: "we are warranted in concluding that the drumming of the ruffed grouse is made solely by the wings striking the feather cushions of the sides, that it is purely a mate call, and that the reaction is definitely inherited."

Dr. R. M. Yerkes, of the Harvard Psychological Laboratory, contributed to the July number of the Journal of Comparative Neurology and Psychology the results of his recent investigation of the sense of hearing in frogs. Those who have noticed in the laboratory the unsatisfactory evidence, given by the frog, of stimulation by noises, will be interested in the writer's conclusion that sounds alone never cause motor reactions; but when accompanied by visual or tactual stimuli sounds reinforce the visual or tactual reactions. Such reinforcement does not occur when the auditory nerves are cut. It therefore appears that a fairly well developed sense of hearing is present.

Kongl, Fysiografiska Sällskapet Handligar, N. F., Bd. 16, has two recent articles by Dr. Hans Wallengren which contain matter of interest to zoology teachers who make use of fresh water mussels in the laboratory. Zur Biologie der Muscheln I, Die Wasserströmeengen, has 62 pages of text, 3 plates and several text figures devoted to a study of the

afferent and efferent currents of water in certain species of Unio Anodonta, Mytilns, Mya and Ostrea. By means of ingenious apparatus, described in detail in the text, Dr. Wallengren was enabled to reach quite certain conclusions concerning the variability in the strength of such currents under different conditions.

The apparatus included a pendulum of aluminium wire suspended from a horizontal axis which was supported by needle points. The lower part of the pendulum which was immersed in the water containing the specimen was hammered thin in the direction in which it would afford the least resistance in moving through the water. To its lower end was attached a thin plate placed transverse to the current of water issuing from the cloacal opening of the specimen studied. Through a slit in the wall of the pasteboard box by which the outfit was protected from currents of air, a beam of light from an incandescent bulb, (placed outside the box) and condensing lens was reflected from a mirror attached to the horizontal axis. The beam of light was received on bromsilvergelatin paper stretched on a revolving drum; the light passing through a slit in the zinc plate case by which the drum was enclosed.

A comparison of the path of the ray of light on the sensitive paper, made when the pendulum was acted on by the current, with one made when the pendulum was at rest, made known the presence or absence of variations in the strengeth of the current.

As results of his numerous observations made in different ways the author concludes among other things that in the mussel which is completely at rest (unstimulated) the current flows with uniform strength though with slight regular waves due to the movements of the heart. Irregularities or stoppage in the current are due to muscle contractions and are always the result of stimuli. The efferent and afferent streams are so interdependent that any alteration in one is correlated with a corresponding alteration of the other. The pallial ciliation of the infra branchial chambers is not a factor in producing the afferent and efferent currents but they are produced in the main, by the cilia of the interfilamental canals and the pallial cilia of the supra branchial chambers. When the valves of the shell are closed, there is a water circulation kept up between the infra and supra-branchial chambers.

The second paper, Zur Biologie der Muscheln II. Die Nahrungsaufnahme, is of similar volume and deals with phenomena of alimentation. It is in this connection that the pallial ciliation of the infra-branchial chambers is chiefly involved.

Department of Earth Science. Notes.

CURRENT LITERATURE OF INTEREST TO THE STUDENT OF EARTH SCIENCE.

The Planetesimal Hypothesis, in "Fundamental Problems in Geology," by T. C. Chamberlin, Year-Book No. 3 of the Carnegie Institution of Washington, pp. 195-258.

The Panama Canal, by Rear Admiral Colby M. Chester, U. S. N., National Geographic Magazine, October, 1905.

The Classification of Igneous Intrusive Bodies, by Reginald A. Daly, Journal of Geology, September-October, 1905.

Pleistocene Features in the Syracuse Region, by H. L. Fairchild, The American Geologist, September, 1905.

On the Evolution of the Solar System, by F. R. Moulton, Astrophysical Journal, October, 1905.

The Mineral Matter of the Sea, with some speculations as to the changes which have been involved in its production, by Rollin D. Salisbury. Journal of Geology, September-October, 1905.

ORIGIN AND GROWTH OF RIPPLE MARKS.

The following summary of the results of Mrs. Hertha Ayrton's experiments on the formation of ripple marks is taken from the Proceedings of the Royal Society for April 10th, 1905:

No "Ripple vortices" can form in a current of water flowing steadily in one direction over an obstacle. The ripple mark starts on perfectly smooth sand as a single ridge, wherever the water happens to have the same place of maximum longitudinal velocity during several oscillations. As soon as this sand ridge is high enough (less than a millimetre is sufficient) the water, in flowing over it, forms a spiral vortex with a horizontal axis, which starts a new furrow and ridge in the lee of the first—on one side during one swing and on the other side during the next. The water vortex that forms in the lee of each of these two ripples in turn originates a new ripple there, and in this way fresh ripples are begun with each succeeding swing of the water till the whole sand is ripple marked. Similar experiments might well be devised for the physiographic laboratory. If at any time it should happen that the student is curious to know the cause of the phenomena, it would be in accord with good educational method to give him a chance to try making them with running water or with a pan in which the water and sand can be rocked back and forth.

COSMIC DUST OF SOLAR ORIGIN.

The hypothesis that certain terrestrial phenomena, e. g., magnetic storms and aurorae, are caused by the earth passing through denser portions of streams of finely divided gravitating matter ejected by the sun is discussed by Prof. Schaeberle in No. 4041 of the *Astronomische Nachrichten*. One of the greatest objections to this hypothesis appears to be

that no regularity of period has been discovered for the ejections which would fit in with the observed data of the terrestrial phenomena. Prof. Schaeberle shows, however, that a largely irregular period affords fundamental evidence in favor of the hypothesis.

Both theory and observation lead to the conclusion that the ejective forces on the sun are very variable, and this would certainly mean that the initial velocities of the particles ejected would vary considerably. In a table he has prepared the author shows that particles ejected with an initial velocity of 376.76 miles per second would just reach the earth's orbit, the time taken being 64.6 days. An initial velocity of 381.78 miles per second would carry the particles to four times the earth's distance; their velocity on passing the earth's orbit would be 22.4 miles per second, whilst the time taken to reach the earth on the outward journey would be 29.7 days; 1,003 days would elapse before they crossed the earth's orbit on the return journey. Particles ejected with a velocity of 382 miles per second would cross the earth's orbit with a velocity of 25.9 miles per second in 27.4 days, and would be carried to an infinite distance. Thus a very small change in the initial velocity at which the particles are ejected causes a very large change in the time taken to reach the earth, and therefore Prof. Schaeberle maintains that the irregularity of such phenomena is evidence in favor of the existence of such streams. He also discusses some cometary phenomena which, he considers, furnish the strongest evidence in favor of the hypothesis.—*Nature*, August 24, 1905.

APPARATUS FOR SCHOOLS.

Editor of School Science and Mathematics:

Dear Sir:—Recently, wishing to learn how our school compares with other high schools in regard to the amount of money spent annually for scientific apparatus and supplies, I addressed letters to the science departments of a number of the largest high schools of this and adjoining states, in which I asked for the number of pupils and the number of laboratory periods per week in each science study, together with the amount of money spent this year for apparatus and supplies.

So far replies have been received from fourteen high schools. One of them states that its expenditures are irregular, and another that it has no laboratories, expecting, however, soon to move into a new $400,000 building. The facts concerning the other twelve schools are tabulated below. It may be that some teachers may be able to use this information with their school boards or trustees.

The first seven schools in the table are in this state, the others in adjoining states. The teacher reporting for school No. 9 says that his appropriation is not enough to keep his laboratories in good condition, although his personal efforts in making apparatus amount to about $200 per year. School No. 2 is new, and was fully equipped only a year or two ago. No. 7 is able to get more money when it is needed for anything new, such as X-ray apparatus, etc. No. 10, besides the amount here given, had $400 this year for an electrical outfit. The $1,000 supplied to

Number of Pupils, Number of Laboratory Periods per Week, and Yearly Appropriation for Science Classes.

School.	1	2	3	4*	5	6	7	8	9	10	11	12
Physiology	100 1 to 2		360 1		150	40 2 to 3	275 2	20 1 to 2	200	34 2½	162 2	275 2
Zoology	20 4	90 4	55 3		76	82	275 2	15 1 to 2	20			90 4
Botany		210 4	65 4			380 3	375 2	55 1	20	33 2½	130 2	120 2
Biology											20 4	
"1st Year Science"										337		
Geography	125 0		180 2		200			60 2		7 2½	230 2	60 2
Chemistry	40 4	65 4	20 4		25	175 3	100 2	50 3	20	35 2½	86 4	100 2
Physics	95 4	140 4	100 4		100	250 3	125 2	100 1 to 3	280	122 2½	117 4	150 2
Electricity			13 2					55 2				30 2
Length of Lab. Period.			37 min.			45 min.	45 min.	47 min.		45 min.		45 min.
Total in Science Studies.	380	505	793		551	1070	1150	355	540	568	745	825
Yearly Appropriation. 1905	$ 325	500	800		1000	2300	2000 to 3000	300 to 600	500	800	865	1000

*No. 4 states that his figures are essentially like No. 3's.

No. 5 is the average for ten years. No. 4 thinks they should receive more. So does No. 3.

I would consider it a favor if teachers in schools that have a liberal apparatus allowance, in proportion to the number of science pupils, would communicate the fact to me.

O. C. KENYON,
Syracuse, N. Y.

NOTES FROM THE UNIVERSITY OF ILLINOIS.

On October 14, Prof H. L. Rietz addressed the Mathematical Club on "The Advantages and Disadvantages of Certain Scales of Notation." He gave some reasons why ten had become the base of our system of notation, discussed some effects of changing the base upon the four fundamental operations of arithmetic, and gave some advantages of the base twelve.

On October 28, Mr. E. B. Lytle talked to the Club on "The Definition of a Limit." Miss Nell S. Davis was elected secretary and treasurer to fill the vacancy made by the resignation of Miss Mabel Kilpatrick.

Mr. Edwin R. Smith '05, has been appointed instructor in mathematics in the University of Wisconsin.

Miss Nellie W. Reese '05, has been appointed instructor in mathematics in the Paxton (Ill.) High School.

ERNEST B. LYTLE.

ANNOUNCEMENT.

American Mathematical Society—Chicago Section, Regular Meeting, December 29-30, 1905, University of Chicago.

The eighteenth regular meeting of the Chicago Section of the American Mathematical Society will be held at the University of Chicago, on Friday and Saturday, December 28-30, 1905, the first session opening at 10 o'clock a. m., in Room 36, Ryerson Physical Laboratory.

Titles, abstracts, and time limits of papers to be presented at this meeting must be in the hands of the Secretary of the Section not later than Tuesday, December 5. All abstracts must be in a form suitable for incorporation in the Secretary's report. Papers not in form for publication will be referred to on the programme as preliminary reports.

Programme Committee:

THOMAS F. HOLGATE, Secretary,
GILBERT A. BLISS,
ARTHUR G. HALL.

EVANSTON, ILLINOIS, November 1, 1905.

Owing to the many urgent requests, Dr. Edward F. Bigelow, editor in charge of the department of Nature and Science, in connection with the St. Nicholas Magazine, has decided to make a *second* tour of the state of California in December, 1905, lecturing on the general subject of Nature Pedagogy. These lectures will be given under the auspices of the state authorities of education and various Teachers' Associations. This call for a second tour in 1905 in this state speaks in the highest praise of the splendid work done by him last spring. Luther Burbank speaks of this past master of Nature Study Work only in terms of the highest commendation.

Dr. Bigelow is one of the leading authorities on Nature Study Work in the world. He has frequently contributed to the pages of SCHOOL SCIENCE AND MATHEMATICS.

THE NEW SOCIETY OF TEACHERS OF MATHEMATICS AND THE NATURAL SCIENCES.

The committee on organization is at work on a constitution to be proposed to existing organizations. Its preparation has required more time than was anticipated so that it is impossible to print it in the December number of "School Science and Mathematics." It is expected that it will be ready for the January number.

FRANKLIN T. JONES,
Secretary.

BOOKS RECEIVED.

Laboratory Manual of Chemistry for Secondary Schools. New edition pages 163, by W. A. Morse and F. C. Irwin. D. Appleton & Co., New York.

Meetings.

NEW YORK BIOLOGY TEACHERS.

The Regular Meeting of the New York Association of Biology Teachers was held in the Lecture Room of the Board of Education Building, Park Avenue and Fifty-ninth Street, Friday evening, October 20th, at 8:15 o'clock.

At this meeting Professor W. E. Castle, of Harvard University, delivered a lecture on the following subject:

THE EXPERIMENTAL STUDY OF HEREDITY.

Professor Castle's work in this field has attracted the attention of Biologists throughout the country, and in this lecture presented illustrations of the important results which he has obtained in experimenting with animals.

CHICAGO CENTER.

The first regular fall meeting of the Chicago Center of the Central Association of Science and Mathematics Teachers was held Saturday, October 28, in the Central Y. M. C. A. Building. The address was given by Dr. L. W. Jones, of the University of Chicago. His subject was "Some Recent Work on Allotropic Form of Certain Elements." He spoke with special reference to Tin, Arsenic, Antimony and Sulphur. That which he said concerning the peculiar allotropic condition of tin at a temperature of about 20° C., was particularly interesting and instructive.

This was one of the most interesting meetings which the Chicago Center has held. No one interested in the teaching of Science and Mathematics within a radius of 25 miles of Chicago can afford to miss these monthly gatherings. The President, Mr. W. C. Hawthorne, deserves great credit for the excellent quality of all of the programs which have been prepared during the last year.

A marked advance in sending wireless messages in a given direction has been brought out in Italy by Alessandro Artour, Esq., C.E., who has succeeded in producing circular and elliptical rays of electric waves which are sent forth in any desired direction with great power. Herr Zehnder was the first actually to produce circularly and elliptically polarized electric radiations experimentally, in 1894. His plan was to utilize a pair of plane polarizing grids made of a number of parallel wires attached to a frame and place them parallel to each other a short distance apart and with their wires crossed. These two grids will reflect electric waves in the same manner that wire gauze will reflect light, and if the crossed wires of the grids are separated a distance of one-eighth of a wave-length and the plane of the incident radiation is 45 degrees to the plane of the wires the reflected radiation will be circularly polarized, but if the relations of the planes are changed the polarization will be elliptical.—*Scientific American.*

Book Reviews.

Laboratory Experiments in Chemistry, by B. W. Peet, M. S., Assistant Professor of Chemistry in the Michigan State Normal College, Ypsilanti, 1905. Second edition revised. Price 55 ctc. by mail.

In this edition the author has introduced many new experiments, rewritten and modified others. Part II, The Metals, has been largely rewritten. Among some of the most desirable features are: An excellent and well selected list of reference books and periodicals for the chemical library; directions for making normal solutions of reagents; conversion tables; table of tension of aqueous vapor; a large number of quantitative experiments carefully selected and well written; a title for each experiment. It is intended for a one-year course in secondary schools and is one of the two or three best manuals before the public. C. M. T.

Euclid's Parallel Postulate. By John Williams Withers, Ph. D. The Open Court Publishing Company, Chicago, 1905. 14x20, cm. pages VII+192.

In this thesis, Mr. Withers traces, briefly, the historical origin of the parallel postulate, and indicates the various attempts which were made, previous to the ninteenth century, to dispense with the postulate by,—(1) the substitution of different definitions, (2) the substitution of different postulates, and (3) the proving of the postulates on the basis of Euclid's other assumptions. He then outlines the underlying principles of the non-Euclidean systems, of geometry, discovered by Lobatchewsky, Bolyai, Riemann, Helmholtz and others. From this historical outline he passes on to attempt, (1) "to orient the problem and point out its complex relations," (2) "to trace the parallel postulate and its closely allied conceptions to their psychological sources;" (3) "to determine the nature and validity of this postulate and its place in geometrical systems;" and (4) "to indicate the conclusions which seem to follow from this discussion as to the nature of space." From the psychological side he concludes that, "it is not only conceivable, but empirically possible, that an appreciable deviation of the parallel postulate from the space of experience, may eventually be found." As to the validity of the postulate he states that "if we consider the larger realm of spatial experiences in which sensations of motion, direction, and touch are all involved, all the known facts inevitably suggest the parallel postulate." Whether after further investigation they shall continue to do so, remains to be seen In his final chapter he discusses briefly the resulting implications as to the nature of space.

This thesis gives evidence of careful and thorough investigation on the part of Mr. Withers, and should be found decidedly helpful and suggestive to the student of research. J. V. McNALLY.

American Insects, by Vernon L. Kellogg, Professor of Eutomology and Lecturer on Bionomics in Leland Stanford Jr. University. (Henry Holt and Company, New York City.)

This is a volume of six hundred and forty-seven large octavo pages, illustrated by over eight hundred figures in black and white and ten

excellent colored plates. It contains the outlines of insect anatomy and physiology and a skeleton classification, but this technical framework is used mainly to give form and systematic connection to a large body of valuable and interesting matter on the biology and ecology of insects, of which the greater part of the work consists.

The first sixty pages contain a succinct and useful discussion of the general anatomy, the special physiology, the development, and the general classification of insects, after which, in the next five hundred pages, the orders are treated in succession, with analytical keys to the families of each. The last chapters of the book are given to general topics—insects and flowers, color and pattern and their uses, and insects and disease,—an appendix following on the methods and materials of the field and laboratory entomologist. Under the various orders in the body of the work, the principal families and the more important species are discussed from the standpoint of the biologist rather than that of the collector or the technical entomologist, and the reader's imagination is constantly drawn to the fields and forests where this fascinating population finds its home.

The work is scientifically conceived and carefully executed in every part; but it is free from all unnecssary tchnicalities, and so fresh in its spirit and so informal in its tone that one scarcely remembers in reading it the scientific attainments of its eminent author. It is a storehouse of biological information drawn from authoritative sources and vivified by contributions from the author's own rich experience as an observer and an investigator. The behavior and the habits of insects, their adaptations, life histories, and social and economic relations are the leading topics throughout, but all practicable aid consistent with the general plan of the work is nevertheless given to the amateur who wishes first of all to know, at least in a general way, the names and relationships of the commoner and more interesting insects of his neighborhood.

The style is vivacious, flowing, correct, as pellucid as a mountain brook, and free from all those affectations of sprightliness or sentiment which seem likely to become conventional in the literature of nature study. The teacher of biology is especially to be congratulated that he has at his comand so rich, reliable, and attractive a store of available knowledge as is offered him in this charming book.

S. A. Forbes.

PHYSICS.

By Charles R. Mann, University of Chicago and George R. Twiss, Central High School, Cleveland, Ohio.

Scott, Foresman & Co., Chicago, 1905.

13.3x29.5 cm., x+453 pp.

This text is a radical and refreshing departure from the usual plan of presenting high school physics. It reminds one somewhat of Sanford's physics for high school students in that the topics are considered concretely and practically at first, and definitions are used only when a need for them is seen. Interest in the subject is sought by beginning each topic with a reference to the pupil's experience and usually to "something that goes," to use the words of the authors.

In the preface, the authors state that they have endeavored to assist the teacher: I. by presenting the subject so that the pupil's interest is easily aroused; II. by developing the scientific habit of thought, and III. by developing some principles from the historical standpoint, so that the student may obtain somewhat of "the hero-ology of the science" and that they may have a vivid idea of the growth of the subject. In general, physical rather than mathematical arguments are employed.

The book is divided into twenty-three chapters, each of these considers related topics and is a "continuous" argument toward some principle or principles. At the end of the several chapters are found special features, carefully worked out, which add much to the value and efficiency of the text. These are: I. a concise *summary* of the principles and ideas developed in the chapter; II. a *series of questions,* covering the whole ground, to assist the pupil in preparing his lessons and in reviewing; III. a set of *problems* to test the application of principles; IV. a series of paragraphs containing *suggestions* to *students.* These contain references to other books, suggestions for the construction of simple apparatus and for performing helpful experiments.

While the question of best order of subjects in physics will never be settled to the satisfaction of every one, yet it is doubtless true that the order of this text is the one best suited to the average laboratory, viz.: mechanics, heat, electricity, sound and light.

In mechanics, the omission of some topics usually presented may seem a defect to many teachers accustomed to the ordinary methods of presenting the subject, e. g., there are omitted the classes of levers, forms of equilibrium, law of gravitation, and properties of matter which are not considered in a separate chapter or paragraph, some ideas are emphasized which are not always found in high school physics, as, graphical methods, vectors and the discussion of efficiencies of engines.

Mention should not be omitted of the illustrations. These are mainly from photographs and form a striking and attractive feature of the book. The general plan of the text is excellent. It is interesting, helpful and should stimulate the enthusiasm and interest of any class. It is undoubtedly one of the best books on high school physics that has appeared.

WILLIS E. TOWER.

AMENDMENT TO CONSTITUTION OF C. A. S. M. T.

The following proposed amendment has been received: That Past Presidents be *ex officio* members of the Executive Committee.

C. M. TURTON, Secretary.

Index to Volume IV.

A

ANEMOGRAPH, A SIMPLE—E. Marsh Williams 159

B

BIOLOGY AS AN ADDED INTEREST IN LIFE—A. J. Grout 31
BOOK REVIEWS
SEGERBLOM'S OUTLINE OF ELEMENTARY CHEMISTRY; PEET'S LABORATORY EXPERIMENTS IN CHEMISTRY 45
WALTER'S WILD BIRDS IN CITY PARKS 105

C

CHEMICAL LABORATORIES, SOMETHING NEW IN—Harry N. Wheaton 138
CHEMICAL EQUATIONS, A SIMPLE DEVICE WITH—Eldred E. Jungerich 92
COLLECTION POLE, A FOLDNG—Louis Murbach 96

D

DEVICE FOR ILLUSTRATING THE PERIODIC LAW, A SIMPLE—Charles Baskerville 37
DO GRASSHOPPERS DRINK?—Charles D. Snyder 90

E

EXTENSIMETER, A SIMPLE—H. N. Chute 157

F

FUNCTIONS OF NATURE STUDY AND WHAT IT CAN DO AS A PREPARATION FOR HIGH SCHOOL BIOLOGY, THE—Gertrude A. Gillmore 136

H

HIGH FREQUENCY COIL, A HOME MADE—N. Henry Black 151

I

IS THE COURSE FOR COLLEGE ENTRANCE REQUIREMENT BEST FOR THOSE WHO GO NO FURTHER?—Otis W. Caldwell 15

L

LABORATORIES OF THE MASSACHUSETTS STATE BOARD OF HEALTH AND THE METHODS EMPLOYED THERE— 129

M

METROLOGY
THE METRIC SYSTEM PSYCHOLOGICALLY CONSIDERED—William F. White 40, 103, 163
NOTES 169
MODIFIED DEMONSTRATION PRESSURE GUAGE, A—Edwin H. Hall 35

N

NEW EXPERIMENTS, SOME EXPERIENCES WITH,—R. Sprague 140
NOTES, CHEMISTRY, PHYSICS, PHYSIOLOGY 170
NOTES ON THE PROGRESS OF CHEMISTRY—Lyman C. Newell 99

O

OBSERVATION WORK CONNECTED WITH ALMANAC DATA—G. W. Myers 145

P

PEDAGOGICAL BEARING OF CHEMISTRY ON PHYSICS, THE—Arthur John Hopkins 22
PHOSPHORUS, A NEW LECTURE TABLE EXPERIMENT WITH—Edward H. Kraus 95
PLEA FOR STUDENT LABORATORY WORK IN A FIRST COURSE IN PHYSICS—W. T. Monterieff 72
PROBLEM OF TEACHING DYNAMICS IN THE HIGH SCHOOL, THE—F. D. Barber 80
PLANTS AS PETS—Edward F. Bigelow 87

Q

QUANTITATIVE EXPERIMENTS, TWO NEW—Rufus P. Williams 97

R

RATIO OF QUANTITATIVE TO QUALITATIVE EXPERIMENTS IN CHEMISTRY, THE—H. P. Talbot 34
REFRACTION OF WATER, THE INDEX OF—V. D. Hawkins 160
REPORTS OF MEETINGS
N. E. ASSOCIATION OF CHEMISTRY TEACHERS; N. Y. STATE SCIENCE TEACHERS ASSOCIATION 47
EASTERN ASSOCIATION OF PHYSICS TEACHERS; CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS CLEVELAND SECTION; THE MICHIGAN SCHOOL MASTERS CLUB-CONFERENCES OF PHYSICS AND CHEMISTRY, AND BIOLOGY 106
ONTARIO EDUCATIONAL ASSOCIATION; EASTERN ASSOCIATION OF PHYSICS TEACHERS; N. E. ASSOCIATION OF CHEMISTRY TEACHERS 174

S

SHOULD THE STUDENT BE DIRECTED TO EMPHASIZE ONE POINT ONLY IN EACH EXPERIMENT, OR SHOULD HE BE HELD RESPONSIBLE FOR ALL RELATED PHENOMENA?—H. N. Goddard 61

T

TEXTBOOK IN ELEMENTARY CHEMISTRY, THE—William McPherson 1

V

VALUE OF FIELD AND HERBARIUM WORK, THE—William P. Holt 121
VALENCE, A LECTURE EXPERIMENT ILLUSTRATIVE OF—Launcelot W. Andrews 143

Index to Volume V.

A

ACID AND ALKALI-PROOF LABEL FOR REAGENT BOTTLES, A SIMPLE—E. P.Schoch 347
AIMS AND METHODS OF THE HIGH SCHOOL COURSE IN ZOOLOGY—J. G. Hutton . 230
ALGEBRA BY THE LABORATORY METHOD, THE TEACHING OF—C. W. Newhall . 40
ALGEBRAIC BALANCE, AN—F. C. Donecker 411
ALGEBRAIC BALANCE, ANOTHER—N. J. Lennes 602
AMERICAN MATHEMATICAL SOCIETY, CHICAGO SECTION 775
AN OPEN LETTER 111
ARGUMENT FOR TEACHING ARITHMETIC, GEOMETRY AND ALGEBRA TOGETHER IN THE FIRST YEAR OF THE HIGH SCHOOL, THE HISTORICAL—Willard S. Bass 712
APPARATUS FOR MEASUREMENT OF THE GROWTH OF A PLANT—G. W. Low . . 27
APPARATUS FOR SCHOOLS—O. C. Kenyon 773
APPARATUS FOR TRANSMITTING GAS FROM ONE VESSEL TO ANOTHER—J. A. Giffin 195
ASSOCIATION OF MATHEMATICAL TEACHERS IN NEW ENGLAND, REPORT OF THE THIRD SPRING MEETING OF THE 504
ASSOCIATION OF ONTARIO, NATURAL SCIENCE TEACHERS 586
ASTRONOMY AS A HIGH SCHOOL SCIENCE—J. A. Miller 415
ATOMS DIVISIBLE, ARE—Arthur A. Skeels 533, 610

B

BACTERIOLOGY IN PUBLIC SCHOOLS—W. H. Manwaring 52
BAROMETER TUBE, NOTE ON FILLING A—N. F. Smith 459
BEGINNING CHEMISTRY, WHAT SHOULD BE TAUGHT IN—F. S. Kedzie 309
BIOLOGY NOTES 58, 303, 367, 584
BIOLOGY, REPORT OF COMMITTEE ON 50
BIOLOGY SECTION, NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION—W. M. Smallwood 291
BOILING POINT, INFLUENCE OF PRESSURE ON THE—J. A. Giffin 55
BOOKS RECEIVED 220, 597, 683, 775
BOOK REVIEWS 220, 305, 505, 592, 681, 777
BOTANICAL NOTES 481
BOYLE'S LAW, APPARATUS TO ILLUSTRATE—H. L. Curtis 187
BOYLE'S LAW BY MEANS OF A CAPILLARY TUBE—C. H. Perrine 48

C

CELL, A NEW FORM OF—Walter P. White 460
CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS AND ITS LOCAL CENTERS—W. A. Fiske 500
CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, FIFTH ANNUAL MEEETING OF THE 591, 677
CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, REPORT OF MEETINGS 61, 117
CHEMISTRY NOTES 581
CHEMISTRY, SYLLOBUS IN 579
CHEMISTRY, THE EDUCATIONAL VALUE OF THE HISTORY OF—H. N. Goddard . 523
CHICAGO CENTER, C. A. S., AND M. T. 283, 588, 776
CIRCULAR MOTION, THE ELEMENTS OF—Francis E. Nipher 541
COLLECTION OF ROCKS, MINERALS AND SOILS, A SCHOOL—George W. Low . . 520
COOLING OF AIR BY EXPANSION, A SIMPLE EXPERIMENT ON THE—Albert B. Porter 250
COPYING STAND, A CONVENIENT—Fred A. Holtz 544

CORRECTION ON MAP CONSTRUCTION, A 465
CORRELATION OF THE DIFFERENT BRANCHES OF COLLEGE MATHEMATICS DESIRABLE FROM THE TEACHER'S STANDPOINT, TO WHAT EXTENT IS A CLOSER—W. H. Wilson 235
COUNTING, THE BEGINNINGS OF—Levi L. Conant 385
"COUNTRY LIFE IN AMERICA" 280
CULTURE COURSE IN MATHEMATICS, A—T. M. Blakslee 645, 752

D

DECREASE IN THE NUMBER OF PUPILS OF CHEMISTRY IN HIGH SCHOOLS, ITS CAUSE AND REMEDY—James E. Armstrong 107
DENSITY OF A SOLUTION OF HYDROCHLORIC ACID, THE—F. C. Irwin 443
DESIRABLE PRODUCT FROM THE TEACHER OF MATHEMATICS, THE POINT OF VIEW OF AN ENGINEERING TEACHER—Dugald C. Jackson 67
"DIE UNTERRICHT," NOTES FROM 283
DYES, EXPERIMENTS WITH—Warren R. Smith 451
DIFFICULTIES OF THE MATHEMATICS TEACHER, SOME—Cora Strong 349

E

EARTH SCIENCE NOTES 482, 772
EASTERN ASSOCIATION OF PHYSICS TEACHERS, MEETING OF 373, 589
ECOLOGY IN THE HIGH SCHOOL, PLANT—Will Scott 512
ELEMENTARY DYNAMICS, A NEGLECTED POINT IN THE TEACHING OF—Henry Crew 331
ENRICHMENT OF THE HIGH SCHOOL COURSE IN PHYSICS, THE—John F. Woodhall 223
ENTROPHY AND FREE ENERGY AND THEIR IMPORTANCE IN GENERAL CHEMISTRY, THE PHYSICAL NOTIONS OF—E. P. Schoch 445
ERRATA FOR OCTOBER, 1905 683
ETCHING WITH HYDROFLUORIC ACID, NOTE ON—Nicholas Knight 199
EXPANSION OF DIFFERENT GASES, AN APPARATUS FOR ILLUSTRATING THE EQUALITY OF—C. F. Adams 456
EXPERIMENT TO DEMONSTRATE THAT THE PULSE IS CAUSED BY A WAVE OF PRESSURE AND IS NOT DUE TO THE ONWARD FLOW OF THE BLOOD, AN—S. D. Magers 462
EXPERIENCE AND A REFLECTION, AN—E. A. Strong 538

F

FORCE AS AN ENERGY FACTOR—A. H. Sage 638
FORESTRY IN THE PUBLIC SCHOOLS—A. Neilson 657
FORMULA F=MA, THE MEANING OF THE—G. W. Stewart 539
FORMULA OF WATER 280
FORMULA OF WATER, THE—John Waddell 192
FRENCH MERIDIAN MEASUREMENT, ACCOUNT OF THE—C. S. Wadsworth . . 285
FRICTION, AN EXPERIMENT ON—Albert B. Porter 110
FUNDAMENTAL OPERATIONS, COMPARISON OF THE—Fannie Webster 80

G

GAIN IN WEIGHT OF SULPHUR BURNING IN AIR, AN EXPERIMENT TO SHOW THE—Della M. Stickney and Wm. L. Kleman 93
GALVANOMETER FOR MEASURING RESISTANCE BY THE METHOD OF SUBSTITUTION, A—Arthur W. Gray 599
GAS PIPETTE, A—P. G. Agnew 347
GEOGRAPHY, AN AID TO THE TEACHING OF—Edward King 365
GEOGRAPHY, HIGH SCHOOL—Fred J. Breeze 516

GEOMETRIC FORMS, LIMITS IN—Arthur L. Baker 562
GEOMETRY, NOTES ON—G. W. Greenwood 369
GEOMETRY, THE TEACHING OF—Clara A. Hart 649, 717
GRAPH TRACING—F. C. Boon 398
GRAPH WORK IN ELEMENTARY ALGEBRA—F. C. Touton 557
GREEK MATHEMATICS WHICH ARE USEFUL IN SECONDARY TEACHING, SOME POINTS IN THE HISTORY OF—Julie Servaty 553, 606

H

HAND-BOOK OF AHMES, THE MATHEMATICAL—G. A. Miller 567
HIGH SCHOOL BOTANY, A DISCUSSION OF GENERAL METHOD IN—Elma Chandler 469
HIGH SCHOOL MATHEMATICS CLUB, A—Chas. W. Newhall 323
HIGH SCHOOL SHOP, THE—J. P. Naylor 439
HYGIENE, SIMPLE EXPERIMENT IN—Lillian Chapin 75

I

IMPROVED PORTABLE GAS GENERATOR, AN—Herbert N. McCoy 197
INDEPENDENT CRITICISM, NOTE ON AN—T. M. Blakslee 355
INDEPENDENT CRITICISM OF CURRENT TEXTS, AN—G. W. Greenwood 145
INDIANA STATE SCIENCE TEACHERS ASSOCIATION 489
INDEX OF REFRACTION OF LIGHT FROM WATER INTO AIR, A SIMPLE METHOD OF DETERMINING THE—G. B. Masslick 266
INDEX TO VOLUME IV. 780
INDEX TO VOLUME V. 782
INFLUENCE OF THE TEACHER'S RESEARCH WORK UPON HIS TEACHING OF BIOLOGY IN SECONDARY SCHOOLS—John M. Coulter 94
INSTRUMENTS FOR TOPOGRAPHIC SURVEYING—Willard S. Bass 167
INTRODUCTION OF METROLOGY INTO THE COURSE OF INSTRUCTION IN MATHEMATICS AND PHYSICS, THE—Cleveland Abbe 3

L

LABORATORY MATHEMATICS AND THEIR RESULTS, SOME EXPERIENCES IN—Franklin T. Jones 406
LABORATORY WORK IN PHYSIOLOGY AND HYGIENE, SOME DIRECTIONS FOR ELEMENTARY—L. Murbach 661, 756
LARGE SPECIMENS, NOTE ON MOUNTING—L. B. Gray 584
LATITUDE AND THE LENGTH OF DAY—Joseph F. Morse 334
LECTURES, EXPERIMENTAL—Harry D. Abells 436
LECTURE TOUR, DR. BIGELOW'S 775
LIFE PRODUCED ARTIFICALLY 368
LIMITS IN ELEMENTARY GEOMETRY, THE TREATMENT OF—N. J. Lennes 743
LINEAR EQUATIONS, DUALISTIC PROPERTIES FOUND IN—R. L. Short 273
LISSAJOU'S FIGURES, A NEW METHOD OF PRODUCING—L. V. Case 731
LITERARY NOTES 578
LOGARITHMS IN THE FIRST YEAR OF THE SECONDARY SCHOOL—G. W. Myers . 709

M

MAP CONSTRUCTIONS—W. N. Snyder 29
MATHEMATICAL ANNOUNCEMENT AND REQUEST 384, 508
MATHEMATICAL ASSOCIATION OF WASHINGTON 201
MATHEMATICAL CLUB OF THE UNIVERSITY OF ILLINOIS 300
MATHEMATICAL SOCIETY, SAN FRANCISCO 201
MATHEMATICAL TEACHING, MOVEMENTS IN—David Eugene Smith 135
MATHEMATICS, IDEALS IN THE TEACHING OF—H. E. Slought 702
MATHEMATICS, NOTES 370

MATHEMATICS WITH BIOLOGY, HISTORY AND LITERATURE, CORRELATION OF—Jos. B. Collins 640, 726
MECHANISM OF RESPIRATION, A DEVICE SHOWING THE—G. C. Bush 186
METEOROLOGY, RECENT ADVANCES IN—Henry J. Cox 83, 159
MERCURY, AN EASY METHOD OF CLEANING—B. W. Peet 244
METROLOGY, NOTES 58, 115, 202, 284, 366, 481, 575, 671, 765
METEOROLOGY, APPARATUS FOR INSTRUCTION IN—Cleveland Abbe . . . 690
METRIC SYSTEM IN THE PHILIPPINES, TRIUMPH OF THE—Rufus P. Williams . . 322
METRIC SYSTEM, TENDENCIES TOWARD THE—Hon. James N. Southard . . . 653
MICHIGAN ACADEMY OF SCIENCE, REPORT OF MEETINGS OF THE 483
MISSOURI SOCIETY OF TEACHERS OF MATHEMATICS, THE 497
MOTION, COMPOSITION OF—Albert B. Porter 45
MULTIPLICATION, WHAT IS—A. Latham Baker 104
MUSCLE-LEVER APPARATUS, SIMPLE—L. Murbach 669

N

NEBRASKA SCIENCE TEACHERS ASSSOCIATION 220
NATIONAL SOCIETY OF TEACHERS OF SCIENCE AND MATHEMATICS, ORGANIZATION OF 589
NATURE STUDY—Robert N. Wolcott 316
NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS 490
NEW YORK BIOLOGY TEACHERS MEETING 776
NEW YORK CHEMISTRY TEACHERS' CLUB—M. D. Sohn 296
NEW YORK PHYSICS CLUB, MEETINGS OF 502
NEW YORK SECTION OF A. T. M. M. S. M., MEETING OF 302
NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION 207
NEW YORK STATE SCIENCE TEACHERS' ASSOCIATION, PHYSICS AND CHEMISTRY SECTION 213
NEW YORK STATE TEACHERS' ASSOCIATION, REPORT OF THE MATHEMATICS SECTION 299
NEWS ITEMS 60
SCIENCE INDEX GAL 2 MORRIS VBGKQ MCJYFW PSCHWYPCFWYP FF
NITRIC ACID, ANALYSIS OF—B. W. Peet 346
NORTHEASTERN OHIO CENTER OF THE C. A. S. M. T., REPORT OF THE FEBRUARY MEETING OF THE 308
NOTE TO INSTRUCTORS IN MATHEMATICS—J. E. Gould 301
NOTICE, PUBLISHERS' 683
NUMERICAL EXERCISE IN TEACHING GEOMETRY, ON THE IMPORTANCE OF THE—Arthur Schultze 245

O

OHIO TEACHERS OF MATHEMATICS AND SCIENCE, ASSOCIATION OF . . 218, 380
OSTWALDS' METHOD OF OBTAINING X IN $X=\frac{A}{1-A}$ 466
OUTPUT OF SECONDARY SCHOOLS, PRACTICAL SUGGESTIONS AS TO WAYS OF IMPROVING THE MATHEMATICAL—J. J. Shobinger 401

P

PARALLELOGRAM OF FORCES APPARATUS—Fred A. Holtz 191
PERIODICITY OF THE CHEMICAL ELEMENTS, A GRAPHICAL REPRESENTATION OF THE—Wilhelm Segerblom 38
PHYSICAL GEOGRAPHY, LABORATORY WORK IN—Herbert C. Wood 253
PHYSICS REQUIREMENTS 282
PROBLEMS CONFRONTING THE TEACHERS OF GEOMETRY, SOME—Clarence W. Sutton 139

PHYSIOGRAPHICAL LABORATORY, THE EQUIPMENT OF A—Jane Perry Cook . . 421
PHYSIOLOGY, TEMPERANCE 203, 576
PLANT ACTION IN THE FORMATION OF CAVES AND CLIFFS—J. Paul Goode and Otis W. Caldwell 631
POND, STREAM OR LAKE, AS A STIMULUS TO MORE PRACTICAL WORK IN BIOLOGY AND PHYSIOGRAPHY—R. W. Sharpe 261
PREVENTIVE MEDICINE, THE TRUE FIELD OF—Wilfred H. Manwaring 251
PROBLEM DEPARTMENT 585, 672, 766
PROFESSOR COULTER'S PAPER IN FEBRUARY NUMBER, DISCUSSION OF—L. Murbach 356
PROGRESS IN THE CORRELATION OF PHYSICS AND MATHEMATICS—F. L. Bishop 152
PUBLISHERS' STRIKE NOTICE 597

Q

QUESTION, THE REPLY, A 574
QUINCKE, HERMANN GEORG 283

R

RADIUM, SOURCES OF 249
RECOMMENDATIONS OF COMMITTEE ON PHYSIOLOGY AND HYGIENE 111
REFORM, A MINOR—G. A. Miller 394
REFRACTION, THE USES OF GLASS BLOCKS IN—Henry Garrett 359
RESISTANCE BOX, A SIMPLE—Arthur W. Gray 188

S

SALUTATORY 1
SANITARY MILK INSPECTION A FARCE 676
SCIENCE IN SCHOOLS, THE TEACHING OF—Henry A. Perkins 691
SCIENCE NOTES 371, 582
SCIENCE, TEACHING ON—C. R. Mann 546, 617, 685
SECONDARY SCHOOL BIOLOGY, ECONOMIC AND INDUSTRIAL ASPECTS OF—S. A. Forbes 173
SOCIETIES, SCIENCE AND MATHEMATICAL 307, 383, 684
SOCIETY OF TEACHERS OF MATHEMATICS AND NATURAL SCIENCES, NEW . . 775
SPHERICAL MIRROR, NOTE ON—Edwin H. Hall 281
STATUS OF THE PHYSICAL SCIENCES IN THE HIGH SCHOOL, THE—G. C Bush . 431
STEAM ENGINE, WOODEN MODEL OF—Fred A. Holtz 279
STEAM TRAP, AN IMPROVED FORM OF—Willis E. Tower 200
STEP-UP AND STEP-DOWN APPARATUS, A SIMPLE—De Forrest Ross 551
STORAGE BATTERIES FOR PRACTICAL USE, HOME-MADE—H. R. Bush 268
SUPPLEMENTAL EDUCATION WITH REFERENCE TO SCIENCE TEACHING, ESSENTIALS OF—Walter M. Wood 277
SYLLABUS IN CHEMISTRY, COLLEGE ENTRANCE EXAMINATION BOARD'S—M. D. Sohn 297

T

TEACHERS' PENSIONS 674
TEACHING OF CHEMISTRY, ON THE RELATION OF RESEARCH TO THE—Charles Baskerville 528
TECHNICAL EDUCATION WITH ESPECIAL REFERENCE TO THE TEACHING OF PHYSICS, SOME ASPECTS OF—H. M. Raymond 15
TERRESTRIAL MAGNETISM 261
TEXT-BOOK AND NOTHING MORE, THE—Otis W. Caldwell 532
THEORY OF LIMITS IN OUR ELEMENTARY GEOMETRIES LOGICAL, IS THE TREATMENT OF THE—Alan Sanders 396

THISTLE-TUBE TO ILLUSTRATE, FILLING—J. A. Giffin 725
TROPICAL FRUITS—Mel T. Cook 478, 509, 622, 698

U

UNIVERSITY OF ILLINOIS, NOTES FROM 465, 673
UNIVERSITY OF ILLINOIS, SCIENCE COURSE IN THE 384

V

VACUA, PRODUCING HIGH 465
VACCINATION, THE VALUE OF—Wilfred H. Manwaring 362
VOLUMETRIC COMPOSITION OF AMMONIA, SIMPLIFED APPARATUS FOR THE DETERMINATION OF THE—Linus S. Parmelee 458

W

WATER VAPOR, THE VOLUMETRIC COMPOSITION OF—George A. Hulett . . . 453
WIRELESS MESSAGES 776
WORK OF THE GRADES PREPARE FOR HIGH SCHOOL MATHEMATICS, DOES THE—Mrs. Lizzie Crawford 23

Y

YELLOW FEVER AND MALARIA AT VERA CRUZ, EXPERIMENTAL STUDIES IN . 750

Z

ZOOLOGY AND BOTANY, REPORT OF COMMITTEE ON COURSE OF STUDY IN . 736
ZOOLOGY BEGIN, WHERE SHALL THE COURSE IN—Worrallo Whitney . . . 626
ZOOLOGY NOTES, DEPARTMENT OF 766
ZOOLOGY WORK IN HIGH SCHOOLS, THE CHIEF AIM IN—Frank Smith . . . 339

SAVE MONEY

By ordering your Magazines from our Clubbing Lists.

NOTE THESE OFFERS

School Science and Mathematics ($2.00)

With Cosmopolitan and Review of Reviews ($3.00)	$3.40
" Cosmopolitan, Review of Reviews and Woman's Home Companion ($1.00)	4.00
" Any one of class 1	2.50
" Any one of class 1 and one of class 2	3.50
" Any one of class 1, one of class 2, and any one of class 3	6.00
" Any two of class 1 and one of class 2	4.10
" Any two of class 1, one of class 2 and one of class 3	6.50
" Any one of class 2	3.00
" Any one of class 3	4.50
" Any one of class 2 and one of class 3	5.50

If a new subscription to Education is included, deduct 50c.

CLASS 1
- Cosmopolitan ($1.00)
- American Education ($1.00)
- The Nature Study Review ($1.00)
- Woman's Home Companion ($1.00)
- Technical World ($1.00)
- American Botanist ($1.00)

CLASS 2
- Journal of Pedagogy ($1.50)
- Journal of Geography ($1.50)
- School Review ($1.50)
- Birds and Nature ($1.50)

CLASS 3
- Education ($3.00)
- Educational Review ($3.00)
- Electrical Review ($3.00)
- Scientific American ($3.00)
- Popular Science Monthly ($3.00)
- Review of Reviews ($3.00)
- Country Calendar ($3.00)

Write us for prices of any other combinations in the above list you may wish. Do not delay. Do it *now*.

School Science and Mathematics,

440 Kenwood Terrace **CHICAGO, ILL.**